European Commission

JRC SCIENCE FOR POLICY REPORT

Synthesis report on the evaluation of national notifications related to Article 14 of the Energy Efficiency Directive

Jakubcionis, M., Moles, C., Kavvadias, K., Santamaria, M., Carlsson, J.

2018

Joint Research Centre

EUR 29286 EN

Contact information
Name: J. Carlsson
Address: European Commission, Joint Research Centre, Westerduinweg 3, 1755 LE Petten, Netherlands
Email: johan.carlsson@ec.europa.eu
Tel.: +31-224-565341

JRC Science Hub
https://ec.europa.eu/jrc

JRC112225

EUR 29286 EN

PDF ISBN 978-92-79-88815-1 ISSN 1831-9424 doi:10.2760/368839

Luxembourg: Publications Office of the European Union, 2018

How to cite this report: Jakubcionis, M., Moles, C., Kavvadias, K., Santamaria, M., Carlsson, J., Synthesis report on the evaluation of national notifications related to Article 14 of the Energy Efficiency Directive, EUR 29286 EN, Publication Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-88815-1, doi:10.2760/368839, JRC112225

Synthesis report on the evaluation of national notifications related to Article 14 of the Energy Efficiency Directive

The Article 14 of the Energy Efficiency Directive (EED) obliges all Member States to perform a Comprehensive Assessment of their potential for the application of high-efficiency cogeneration and efficient district heating and cooling, containing the information as set out in the Annex VIII of EED. This report provides an overview of all national notifications received, assesses their overall quality, and makes recommendations for the execution of future Comprehensive assessments.

Contents

Foreword

This work was carried out in the framework of an Administrative Arrangement of the European Commission's Directorate-General for Energy (DG ENER) and the Joint Research Centre (JRC), in which JRC provided technical assistance, analysis and input to support the implementation of Article 14 of Directive 2012/27/EU on energy efficiency. This report is deliverable 3.2.

Acknowledgements

Valuable comments on the content of this report were received from the European Commission's Directorate-General for Energy (DG ENER) - Karlis Goldstein, Ewout Deurwaarder and Eva Hoos.

Authors

Jakubcionis, M., Moles, C., Kavvadias, K., Santamaria, M., Carlsson, J.

Executive summary

JRC has reviewed the technical aspects of the national notifications on their energy efficiency potentials in the heating and cooling sectors. By March 2018 JRC had reviewed all Member States reports.

As this draft report is being written, the European Commission is in the process of sending their feedback on the notifications. Some Member States have already sent updates.

Policy context

The Article 14 of the Energy Efficiency Directive (EED) [1] obliges all Member States to perform a Comprehensive Assessment of their potential for the application of high-efficiency cogeneration and efficient district heating and cooling, containing the information as set out in the Annex VIII of EED.

This report provides an overview of all national notifications received, assesses their overall quality, and makes recommendations for the execution of future Comprehensive assessments. Notable examples of Member States approaches to address different aspects are presented in the report as well.

Main findings

The scope of the comprehensive assessment is very large and it was a major effort for Member States to execute it. Lack of detailed data in the heating and cooling sector impeded the analyses of many Member States. For Member States with limited experience, new tools to perform the analysis often had to be developed.

Assessments of the high-efficiency cogeneration and efficient district heating potentials were performed in most notifications. Significant economic potential of HECHP and EDHC were identified in most Member States. Important potential to reduce losses in existing heat networks were also identified by many Member States.

Most Member States did not perform all elements of the assessments as described in the Energy Efficiency Directive [1] (and the Staff Working Document [2]). The assessments differed significantly in terms of approaches and how data were reported. For example, different parameters to estimate suitable district heating areas were used such as plot ratio, heat demand density, and linear heat density. A few Member States used financial, others economic analyses in the assessments and some both of them. With regard to the way to represent the identified potential, some Member States reported installed capacity and others generated energy. The time horizon of the Cost-Benefit Analyses varied greatly among notifications. Hence, a reliable comparison of potentials identified between Member States cannot be performed. Several of the Member States did not take into account geographical aspects such as matching existing heat sources with sinks, e.g. waste heat from industry to heat cities or nearby renewable heat sources. Although, most Member States have made a significant effort, the limitations mentioned above have dented their comprehensiveness and compatibility.

Several areas were often missing in the Member States' notifications, for example, the progress achieved to introduce new cogeneration in the energy system (based on EC/2004/8) and the primary energy savings.

As mentioned above, the assessments contain several weaknesses, but it is also evident that they have also made Member States more conscious of the energy efficiency potentials in the heating and cooling sector. If these weaknesses will be addressed for the next round of assessments in 2020, then the benefits will be significantly enhanced.

It is recommended that the assessments which will be repeated in 2020 as foreseen by the Article 14 of EED should be based on a more harmonised set of data, more standardized the way that assessments are prepared, and ideally use a reporting template.

This report is structured in a way that each chapter examines the points dictated by Annexes VIII and IX of EED. Each chapter includes detailed findings and recommendations. A summary of those is described below:

Key conclusions and recommendations

Conclusion 1: The wording of the Energy Efficiency Directive Article 14 is occasionally imprecise in describing how the assessments should be performed.[1]

Recommendation 1.1: The Annexes VIII and IX of EED [1] should be updated in order to remove ambiguities, and provide more details on how to perform the analysis. For example, the sectors and technologies to be analysed should be explicitly stated, and the definition of technical and economic potentials given.

Recommendation 1.2: Prepare a template for reporting results in order to harmonise the format or all outputs.

Conclusion 2: Approaches in analysing and reporting vary greatly between Member States. This is partially due to the often imprecise wording of the Article 14 (see above), and because Member States often chose to pursue their own approaches rather than to follow the (non-binding) guidelines of the Staff Working Document [2]. Although, such approaches also allowed identifying energy saving potentials, it is sometimes uncertain whether the full potential was established. Due to these differences, a comparison of results between Member States is often cannot be made.

Recommendation 2.1: A more harmonised approach to analyse the energy efficiency potentials in all Member States should be established. This can be achieved by updating the Annexes VIII and IX of EED. An updated JRC Guidance [3] would also support the process.

Recommendation 2.2: The reuse of old analyses employing different methodologies and approaches significantly deviating from the ones presented in the EED should not be allowed.

Recommendation 2.3: Consider developing or adapting a current energy system tool for the purpose of these types of assessments. It could be developed for instance in the framework of a European project. Several advantages could be derived from this, e.g.:

- support Member States not having good modelling tools available, since it would likely improve their assessments;
- harmonisation of data collected for comprehensive assessments;
- facilitate exchange of experience between Member States.

Conclusion 3: Member States often lacked detailed data for the heating and cooling sector, which reduced the accuracy of the analyses.

Recommendation 3.1: Data collection in the heating and cooling sectors should be improved at Member State level. More advanced Member States in this domain, e.g. Denmark, could share their data collection practises in the heating and cooling sector with other Member States. This could be done for example by arranging workshops.

Recommendation 3.2: EUROSTAT should collect more data on the heating and cooling sector. This would at least include space heating and hot water production in the residential, tertiary and industry sectors, as well as process heating in industry. Also collection of cooling consumption data in the residential, tertiary and industrial sectors should be initiated. EUROSTAT has gradually increased the scope of data gathering in heating and cooling, but it is still significantly less covered than the power sector.

[1] The Staff Working Document and the JRC Guidelines were prepared in order to support Member States in performing their assessment. However, these were not legally binding documents.

<u>Conclusion 4</u>: Several Comprehensive Assessments evaluated only limited number of technologies, namely high-efficiency cogeneration and efficient district heating and cooling, since only those were explicitly required by the EED.

<u>Recommendation 4.1</u>: For a complete analysis of the heating and cooling sector, more technologies and heat sources other than high-efficiency cogeneration and district heating and cooling should be systematically analysed, e.g. waste heat from industries, renewable heat sources and heat pumps. The technologies to be analysed could be listed in the updated Annexes of EED. If a Member State thinks that a certain technology is not applicable to their situation then they can provide exclusion reasoning.

<u>Recommendation 4.2:</u> Consider including analyses of accelerated thermal insulation of buildings in CA, in order to ensure a cost-efficient mix of efficient/low-carbon heating and cooling solutions with thermal insulation levels of buildings.

<u>Conclusion 5:</u> The share of cogeneration in the gross electricity generation has increased in one half and decreased in the other half of EU Member States between 2004 and 2014, according to EUROSTAT data. The economic cogeneration potential identified by Member States in 2011 for year 2015 was in most cases not achieved. The data reported on the share of high-efficiency cogeneration, the potential established, and progress achieved in Member States' notifications were often incomplete, and when reported, usually in capacity rather than energy.

<u>Recommendation 5.1:</u> Analyse why the economic cogeneration potential identified in 2011 was not realised by most Member States. It should be clarified whether it is due to weak energy policies, a new market situation (e.g. low fossil fuel prices, low CO_2 emission right prices, more variable RES in the energy system, low electricity prices), or something else.

<u>Recommendation 5.2:</u> Analyse why cogenerated electricity generation increased in some Member States and decreased in others.

<u>Recommendation 5.3:</u> Identify the most efficient support schemes to cogeneration by comparing progress achieved by Member States.

<u>Recommendation 5.4:</u> Future comprehensive assessments should use energy generation and share of gross electricity generation when reporting progress of cogeneration (not just capacity). This is more consistent with the reporting of identified potential in the same assessments.

<u>Conclusion 6</u>: Member States did mostly not report on new strategies, policies and measures. Instead, many Member States chose to explain the existing strategies, policies, and measures, but these did often not comply with the requirements of the Energy Efficiency Directive.

<u>Recommendation 6.1:</u> Clarify why most Member States did not report it.

<u>Recommendation 6.2</u>: The development of new strategies, policies and measures should be reinforced.

<u>Recommendation 6.2:</u> Identify and share best practices for implementation among the Member States, especially via bilateral and regional cooperation where sharing solutions is most relevant.

1 Introduction

EU Member States together with the European Commission and the European Parliament have agreed on several instruments aimed at improving the energy efficiency in society, notably the Energy Efficiency Directive, Energy Performance of Buildings Directive, Ecodesign Directive and the Energy Labelling Directive. In the "Clean Energy For All Europeans" package, it is stated that the energy efficiency should be the first priority. The proposal for the revised EED includes a binding target of 30 % by 2030.

As one of the measures of the instruments mentioned above, the Article 14 (Promotion of efficiency in heating and cooling) of the EED requires Member States to perform a Comprehensive Assessment of their energy efficiency potentials in the heating and cooling sector. The CA is performed through a Cost-Benefit Analysis (CBA) covering their territory based on climate conditions, economic feasibility and technical suitability. The CBA should facilitate the identification of the most resource- and cost-efficient solutions to meet heating and cooling needs. Policies to realise the identified potentials should then be adopted. The deadline to submit the reports was on the 31st December 2015.

The Annex VIII of EED requires the Member States to prepare:

— a description of the current heating and cooling demand;
— a forecast of heating and cooling demand for the coming 10 years;
— a heat map of the national territory identifying e.g. heating and cooling demand points, potential heating and cooling supply points and other information;
— identification of demand that can be met with high-efficiency cogeneration (HECHP) and efficient district heating and cooling (EDHC);
— identification of the potential for additional high-efficiency cogeneration;
— identification of energy efficiency potentials of district heating and cooling infrastructure;
— strategies, policies and measures that may be adopted up to 2020 and up to 2030 to realise the identified potential of high efficiency technologies;
— report of the share of HECHP and the potential established and progress achieved under Directive 2004/8/EC;
— an estimate of the primary energy savings;
— an estimate of public support measures with the annual budget and identification of the potential aid element.

This report reviews the technical aspects of the Member States' assessments and compares them. It should be noted that comparison is not the primary aim of the requirements of the Directive, which is to assess potential for cost-efficient solutions to meet heating and cooling needs efficiently and serve as a basis for national policies to follow-up.

This report follows the structure of Annex VIII of EED. The CBA is analysed along with the identification of the potential for additional HECHP; in fact, the CBA is a broader analysis that includes that element.

Each chapter contains a sub-section with recommendations how the process and future CA can be improved. Finally, each chapter contains useful examples of the approaches Member States employed to perform their assessments. The useful examples should be seen as complements that might be included in the updated Best practise guidelines prepared by JRC [3].

2 Heating and cooling demand description

2.1 Background

The description of the heating and cooling demand should relate to real, i.e. measured and verified, consumption information as provided, for example, in national and European energy statistics, national energy balances or NREAPs of 2009/28/EC. It should provide information about the heating and cooling consumption of industrial, services, agricultural and household sectors. [2]

2.2 Results

A general overview of heating and cooling demand descriptions principles is summarised in Table 1.**Error! Reference source not found.Table 1**. General overview of heating and cooling demand description principles identified in different reports

Member State	Base year	Quantification of		Sectors	Geographical disaggregation (as presented in the report)
		heating demand	**cooling demand**		
AT	2012	Yes	Yes	(2) Residential and commercial buildings (one value), industry	Country level
BE – Fl.	2012	Yes	Partially (services)	(3) Buildings, small scale industry, large scale industry	Region level
BE – Wa.	2012	Yes	Yes	(3) Residential, services, industry	Region level
BE – Br.	2012	Yes	Yes	(3) Residential, services (7 subsect.), industry (7 subsect.)	Region level
BG	2014	Yes	Yes	(5) DH networks, industry, households and service buildings not connected to DH, agriculture. Cooling demand not disaggregated	Districts
CY	2013	Yes	Yes	(4) Residential, service, industry, agriculture	Country level
CZ	2013	Yes	No	(3) Residential, services, industry (includes agriculture and forestry)	Country level
DE	2012	Yes	Partially (industry)	(3) Residential, services, industry (14 subsect.)	Country level
DK	2013	Yes	Yes	No disaggregation	Country level
EE	Not clear	Partially	No	(4) Residential, services, industry and agriculture	Country level
EL	2010	Yes	Yes	(4) Residential, services, industry and agriculture	Country level
ES	2013	Yes	Yes	(3) Residential (2 subsect.), services (15 subsect.), industry (16 subsect.)	Climatic zones
FI	2010 heating, 2015 cooling	Yes	Yes	No disaggregation	Country level
FR	2013	Yes	No	(4) Residential, services, industry, agriculture	Country level
HR	2013 services, industry 2015 residential	Yes	Yes	(3) Residential, services, industry	Country level
HU	2015	Only DH use	No	No disaggregation	Country level
IE	2015 (date of report)	Yes	No	(3) Residential, services, industry. Agriculture not included	Country level

IT	2013	Yes	Yes	(4) Residential, service, industry (12 subsectors), agriculture and fishery	Region level (residential and service heating) and country level (residential and service cooling, industry and agriculture)
LV	2014	Yes	No	(3) Residential, services, industry	Country level
LT	2012	Only DH use	No	(3) Residential, services, industry	Country level and selected DH networks
LU	2012	Yes	Yes	(3) Residential, services (includes agriculture), industry	Country level
MT	2013	Yes	Yes	(4) Residential, services, industry, agriculture	Country level
NL	2008	Yes	Yes	(4) Residential, non-residential, greenhouses, industry	Country level
PL	2012	Yes	Yes	(4) DH networks, residential and service buildings not connected to DH networks, industry. Cooling demand not disaggregated	Voivodeships (NUTS-2)
PT	2014	Yes	Yes	(4) Residential, services, industry, agriculture and fishery	Country level
RO	2013	Yes	No	(2) Residential, services	Country level
SE	2011	Only DH use	DC use only	No disaggregation	Country level
SI	2014	Yes	Service sector only	(3) Residential, services (6 subsectors) and industry	NUTS-3
SK	2014	Yes	No	(2) DH, individual heat supply systems (households and services)	Country level
UK	2012	Yes	Yes	(4) Residential, Commercial, Public, Industry (includes agriculture)	NUTS-1

Source: JRC analysis, 2017

2.2.1 Base year

The base year was in most cases 2012 or 2013. The oldest set of data used 2008 as base year. However, when performing a CA it should be based on the newest data available, since data from 2008 increases the uncertainty in the analysis.

Some reports used different base years for heating and cooling, or for different sectors. This might be justified when recent data is only available for one sector or energy use. However, for some countries the difference between base years was 5 years, which can lead to inconsistent results, especially if all energy uses or sectors are analysed together during a CBA.

2.2.2 Heat demand quantification

The Comprehensive Assessment should contain the description of the whole heating demand for the country analysed. All countries provided this information to some degree. Some reports presented the heating demand in units of administrative division (e.g. NUTS-1, NUTS-2 or NUTS-3). One country used heating demand disaggregation on different climatic regions. It should be noted that many CAs probably used more detailed data than presented in the reports, as is evident from the prepared heat maps.

A few countries limited the quantification to the district heating demand, and therefore contained only a partial description of total heating demand.

In most reports the demand was described as useful demand, but some reports described it in the terms of final energy consumption.

Table 2 contains the heat demand quantification, which the MSs provided. As explained above, the data cannot be directly compared between MSs, due to the different methods and boundary conditions employed when performing the CAs.

2.2.3 Cooling demand quantification

Cooling demand description is the weakest part of the demand description in most of the analysed reports. Nine reports contained no description of cooling demand and 3 contained partial descriptions.

Generally, the level of detail in describing the cooling demand was much lower than for heating demand and it usually featured only national numbers without sectorial or geographical disaggregation. The poorer description was often due to the less available data. Several MSs also stated that the level of confidence in estimated cooling demand values was much lower than for heating demand.

Some reports omitted cooling demand description with the motivation that it is negligible in some sectors or the country as a whole.

Table 2 contains the cooling demand quantification, which the MSs provided. As explained above, the data cannot be directly compared between MSs, due to the different methods and boundary conditions employed when performing the CAs.

2.2.4 Sectoral disaggregation

Although EED contains no clear requirement to use sectorial disaggregation for the description of heating and cooling demand, it would allow taking into account the different energy consumption patterns of sectors. Sectorial disaggregation of heating and cooling demand should serve the purpose of the analysis to be performed. The number of sectors or subsectors identified and analysed is directly related with the peculiarities of analysis performed. More detailed sectorial disaggregation should be pursued, if large subsectors differ significantly from one another in terms of consumption patterns and future projections.

The majority of reports contained some degree of sectorial disaggregation of heating demand data. Sectorial disaggregation was absent in four reports. Heating data was estimated for three main sectors (residential, services and industry) in the majority of reports.

Eleven reports also included data on agriculture, while other chose to combine the agriculture with the industry or service sectors. Some reports also included data on fishery, but it most cases it was combined with agriculture. However, independent of the approach chosen, since agriculture is only a small share of the total heat demand, the accuracy of the analyses is usually not affected substantially.

Some reports put large emphasis on the heating demand description for district heating. These reports usually contained only a description of demand in residential and service sectors while omitting industry and agriculture.

2.2.5 Methods used to estimate heating and cooling demand

Methods used to estimate the heating and cooling demand depended on the type of data a particular Member State had access to. A very high level of detail was achieved in the reports where energy consumption was estimated based on separate buildings. Other countries, not having such detailed information, often prepared estimates based on lower administrative division units, for instance LAU-2[2]. In order to fill data gaps or to ensure consistency of estimations different approaches were combined, e.g. statistical data on heat demand on the country level was used and then the total value divided among LAU-2 regions based on their population count. Other reports combined data from different sources on gas and electricity consumption, employment data for service sector, national housing models, national energy consumption statistics and so on.

[2] Local Administrative Units – 2 (formerly known as NUTS 5). It is largely used by Eurostat and other European Union bodies.

The estimation of cooling demand often required many assumptions due to unavailability of good quality data. For instance, one report established a ratio of cooling to heating consumption for each activity where space cooling is typically used. Then assumptions were made on the penetration of cooling in particular applications, which allowed estimating the average cooling consumptions across postal code areas. Or cooling consumption was estimated for NUTS-2 regions based on a single figure for cooling at national level disaggregated based on population numbers.

Some of the reports contained no description of the methods used to determine heating and cooling demand.

Table 1 presents a summary of the heating and cooling demand estimated by different Member States.

Table 1. Heating and cooling demand per Member States. Note that estimations are not directly comparable, see explanation above for more information.

Member State	Heating demand, TWh	Cooling demand, TWh	Note
AT	137	2.5	
BE – Fl.	135.8	1.4	Cooling demand established only in service sector
BE – Wa.	65.5	0.7	
BE – Br.	11.1	0.3	Final energy consumption
BG	36.9	0.2	
CY	4.6	3.4	
CZ	123.6	N/A	
DE	912	17.6	Cooling in industry only
DK	55.3	9.4	
EE	not clear	N/A	
EL	61.4	9.5	
ES	408.1	51.8	
FI	88.5	1.4	
FR	821	N/A	
HR	25.5	2.1	Cooling demand in industry not indicated
HU	8.9	N/A	Demand in DH systems only
IE	23	N/A	
IT	698.4	6.3	Joint values of heating and cooling demand are reported for industry and agriculture. Cooling demand of residencies and services only
LV	20.2	N/A	
LT	8.6	N/A	Demand in DH systems only
LU	13.8	0.4	
MT	0.54	0.7	
NL	190	3.3	No data on industrial demand. Cooling is assumed to exist only in non-residential sector
PL	235.1	0.28	
PT	61	4.1	JRC asked PT to check this number because of contradicting data in the report
RO	83.9	N/A	
SE	55	1	Only DH and DC supplies
SI	19.1	0.22	Cooling demand only for service sector
SK	34.9	N/A	Doubt whether the whole heating demand of industry is included
UK	484	59	

Source: JRC analysis

It should be noted that the values presented in Table 2 do not always represent the full heating or cooling demand of the given countries due to omitted sectors, decisions to describe only DH demand, assumptions on nonexistence of some energy uses or other reasons. In addition, the years of estimation of demand varies across the reports. Please refer to the Table 1 for description of sectors evaluated in different reports, base years and other details.

2.3 Recommendations for heating and cooling demand description in future Comprehensive assessments

— The CA should include a description of the whole heating and cooling demand, i.e. not only the one provided by CHP and DHC. Currently some reports exclude some sectors, such as industry or agriculture.

— Level of spatial resolution of available data should be improved. In some cases only country level data was used which is not enough to identify spacial relationships between heating and cooling demand areas and potential supply points.

— Cooling demand should be identified at the same level of detail as heating demand. Currently only rough estimates are available on the country scale, if at all.

— The description of the heating/cooling demand should always be made in terms of useful end-use energy (i.e. heat and cooling) and not final fuel consumption. Employing useful energy demand provides a solid basis for evaluation of interchangeability of different heating and cooling technology shares with different efficiencies.

— Further sectorial and even sub-sectorial disaggregation of heating and cooling demand should be encouraged in the cases when it would significantly increase the accuracy of the CA. Ultimately, the level of sectorial disaggregation should be related with the scrutiny of the selected approach.

— MSs followed very different approaches to estimate current heating and cooling demand, resulting in diverse levels of detail and reliability. Procedures and methods for data collection and estimation of heating and cooling demand should be improved and harmonised.

— Estimated heating and cooling demands of different countries in many cases are incomparable. Reports used different sectorial disaggregation, excluded some sectors or energy uses and used different base years. Therefore, in order to provide better insight into EU wide heating and cooling consumption tendencies, the energy efficiency progress and opportunities, as well as to create common policies to realise those opportunities, a common procedure to estimate heating and cooling demand should be agreed upon. Such a procedure should define the sectors for which heating and cooling demand should be described, which year should be used as a base year, which energy uses should be included and so on.

2.4 Best practices of heating and cooling demand descriptions in MS's reports

— The report of Austria identified heating and cooling demand in buildings using very detailed disaggregation of building stock. Residential buildings were divided into 92 categories, consisting of different combinations of 4 building sizes (detached house, semi-detached house, small apartment buildings and large apartment buildings), 8 construction periods (pre 1919, 1919-1944,…, new buildings) and 2 statuses of renovation (renovated or non-renovated). Similarly, service sector buildings were divided into 45 categories, representing combinations of different types (hotels, retail buildings, workshops, etc.), 4 construction periods and 3 size classes. Prerequisite to such detailed disaggregation is the possession of adequate data sources. Data for the analysis was taken from a number of statistical reports and censuses on buildings and their energy consumption, performed over the year by Austrian statistical service as well as other organizations[3]. Since some of these reports are rather old, the results of demand were adjusted to the base year using a recent energy balance of Austria.

- The Spanish report (Chapters 2 and 3) contains a description of disaggregation of heating and cooling consumers. The main data source was the official Land Registry of Spain where all urban, rural and special properties are obliged to be registered. The description of each property in the Registry includes its physical characteristics, including location, use, surface area, etc. All properties were assigned to one of 144 land use categories. At the later stages, the number of categories was lowered to 40 by grouping some uses based on the common characteristics. The examples of final land use categories are collective dwellings, single dwelling houses, offices, industry-beverage, etc. Given the large size of Spain's territory, the authors also added supplementary division of some of the above mentioned 40 categories into 3 climatic regions. Such subdivision was used for those categories were climatic conditions influence energy consumption patterns, as is, for example, the case of residencies. The report also contains a description of supplementary data sources and assumptions used to estimate heating and cooling demand of energy users belonging to different land use categories.
- In the UK report, the annual heating consumption and the coordinates of each individual demand point (building, installation or existing district heating and cooling system) were estimated based on a number of national statistical data sets and other available data sources. Data sources used included energy consumption statistics by sectors, sub-national statistics on the consumption of gas and electricity, employment data, census data on the type of heating technology used by dwelling type, heating fuel consumption data from housing models, data on building locations, etc. A complete list of data sources used can be found in the Table 2.1 of UK report. The analysis involved processing and combining data on fuel consumption at various spatial resolutions, heating energy use, employment statistics and building coordinates. Using such approach heat consumption was determined for each individual property in the UK.

3 For complete list of data sources used please see section 2.1.1.1 of Austrian report (p.8 of English version)

3 Heating and cooling demand forecast

3.1 Background

The heating and cooling demand forecast should take into account the likely evolution of heating and cooling demand in different sectors. The evolution of heat demand in buildings and in different sectors of industry should be given specific consideration. This might include an analysis of the impact of energy efficiency improvements in buildings, such as those required under the Energy Performance of Buildings Directive (2010/31/EU) and the EED. [2]

3.2 Results

A general overview of heating and cooling forecast principles identified in different reports is summarised in Table 2.

Table 2. General overview of heating and cooling demand forecasts principles identified

MS	Timeframe of forecast	Heat demand forecast	Heating demand change	Cooling demand forecast	Cooling demand change	Sectors	Main drivers
AT	2025 industry 2050 buildings	Yes	- 6% (BAU)	Yes	+4%	(2) Residential and commercial buildings (one value), industry	Growth of buildings stock, potentials and policies, improvements in energy efficiency, energy prices, climate data
BE – Fl.	2035	Yes	- 3%	No	No	(3) Buildings, small scale industry, large scale industry	It is mentioned that forecast takes into account existing sector specific developments and policy measures
BE – Wa.	2030	Yes	+-0%[4]	No	No	(3) Residential, services, industry	Changes in degree days, energy performance, average surface area and number of dwellings, changes in heating needs and changes in the value added
BE – Br.	2030	Yes	-5%	Yes	-7 % services	(3) Residential, services, industry	Improved building energy performance and number of dwellings, changes in heating needs per unit of value added and changes in the value added
BG	2025	Yes	-10%	Yes	+150%	Country level	GDP growth, expected decrease in energy intensity, reduced heat transmission losses
CY	2050	Yes	+20%	Yes	+71%	(4) Residential, services, industry, agriculture	Population and GDP change, household consumption, energy prices
CZ	2025	Yes	+3%	No	No	(3) Residential, services, industry (includes agric. and forestry)	Growth of industrial and service sectors, number of households, improvements in energy efficiency
DE	2040 households 2050 industry	Partially (no for service)	-36%	Industry only	+ 31%	(2) Residential, industry	Building renovations, changes in living space; changes in value added, production of raw materials, fuel and electricity intensities, intra-sectorial structural effects
DK	2035 heating, 2030 cooling	Yes	-17%	Yes	+17%	Country level	Not indicated, forecast was taken from external study
EE	2050	DH only	No data	No	No data	Country level	Not indicated, source of the forecast is unclear
EL	2030	Yes	+10%	Yes	+ 25%	Heating: (4) residential, services, industry, agriculture. Cooling: (2) residential, services	GDP with specified elasticity from historical data. This is estimated separately per sector/subsector
ES	No data	No	No data	No	No data	No data	No data
FI	2025 heating, 2030 cooling	Yes	-18%	Yes	+ 21%	Country level	Migration, energy eff. improvements, industrial construction

4 Decrease in residential and service sectors, increase in industry

FR	2030	Yes	-15 to - 24%	No	No data	(4) Residential, services, industry, agriculture	Population and GDP change, energy eff. improvements, policies
HR	2030	Yes	-5%	Yes	+ 52%	Heating: (3) residential, services, industry. Cooling: (2) residential, services	Population, GDP, improvements in energy efficiency and other
HU	2025	Only DH	-10%	No	No data	Country level	Improvement energy efficiency, connecting new users
IE	2025	Yes, but values not presented	No data	No	No data	Impossible to identify	Population change, industrial growth
IT	2025	No	No data	No	No data	(3) Residential, service, industry	Not described
LV	2030	Yes	-8%	No	No data	(3) residential, services, industry	Not described
LT	2030	DH only	-17%(DH only)	No	No data	District heating networks only	Changes in GDP and energy efficiency
LU	2030	Partially	-11% buildings	No	No data	(2) Buildings and industry	Changes in construction and demolition rates, building renovation, policies, energy costs, climatic influences; changes of added values and energy efficiency.
MT	2030	Yes	+ 17%	Yes	+ 27%	(4) Residential, services, industry, agriculture	Population growth, changes in dwelling stock, changes in industry
NL	2050	Yes	-9%	Yes	+ 18%	Country level	Changes in population, housing stock, number of jobs, greenhouse horticulture, demolition rate of old buildings, rise in ambient temperature (climate change)
PL	2025	Yes	+ 8%	Yes	+ 200%	(3) Residential, services, industry, construction and agriculture.	Not indicated, forecast was taken from external study
PT	2025	Partially (no industry)	No change	Partially (no industry)*	No data	(3) Residential, services and agriculture	Not indicated, forecast based on external study
RO	2030	Yes	- 16%	No	No data	(2) Residential and service sectors	Energy eff. improvements, evolution and renovation of building stock
SE	2030	DH only	-7%	For DC	No data	Industry, Multidwelling buildings, commercial premises and detached houses w DH, Other	No data
SI	2035	Yes	-22%	Yes	-15%	(3) Residential, services and agriculture	Household size, market and renovation rate. Efficiency of cooling system in the service sector. Changes in gross added value and energy intensity in industry.
SK	2025	Yes	+ 14%	No	No changes	(2) Individual heat supply and DH systems	Potential energy efficiency of thermal systems, changes in heating consumption of the buildings and in heating consumption in developing urban conglomerations
UK	2025	Yes	- 11%	Yes	- 12 %	(4) Residential, Commercial services, Public services, Industry (includes agriculture)	Population change, economic growth, changing energy costs, policies, changing building stock

* Separate forecasts of heating and cooling demands are not presented; joint values of these uses are reported instead.
Source: JRC analysis

3.2.1 Timeframe of the forecast

All analysed reports provided heating demand forecast for the next 10 years. Four MSs provided demand forecasts till 2050, but usually the forecasts were provided till 2025 or 2030. Although the requirement for the forecast in the Directive is 10 years, it is recommended that the forecast should be as long as the time frame of the CBA. The timeframe for a CBA is typically the same length as the lifetime of the longest serving technology in the study.

3.2.2 Drivers of the forecast

The main drivers used to carry out the demand forecast process were changes in energy efficiency (15 reports), changes in building stock (11), population change (9) and changes in GDP (7). Additional drivers used were climate change, effect of existing policies, changes in industry, energy prices and so on. Table 2 presents the main drivers per MS.

A large number of reports did not present the drivers used for preparing forecasts.

3.2.3 Methods used for forecasting

Some reports prepared forecasts using econometric exponential models, others used different indicators derived from different sources, both European and national. For instance, one report utilised annually updated national energy projections, another used a forecast from a study performed for another purpose.

3.2.4 Sectorial disaggregation

Level of sectorial disaggregation of the heating demand forecast generally followed the same principles as the current heating demand description. Twenty countries provided values for different sectors while six provided only total figures. However, in some reports heating or cooling demands of some sectors were not forecasted while the values for the base year were presented. It should be noted that Annex VIII of EED requires preparing a forecast of changes in the whole heating and cooling demand of the country.

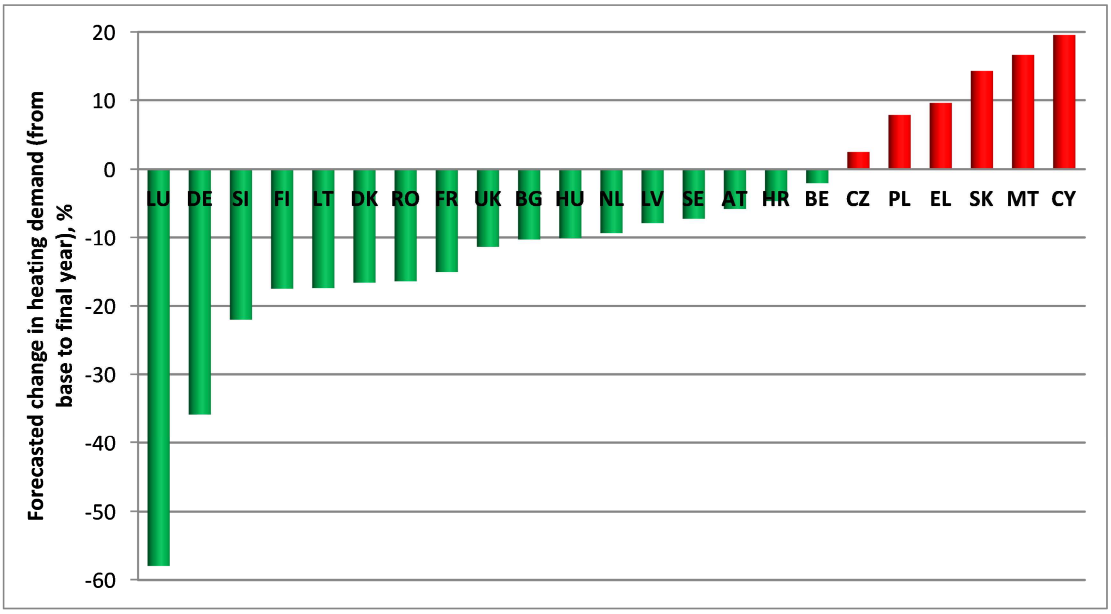
3.2.5 Projected changes in heating demand

The results of the forecasts were varied due to the diverse methods used, e.g. demand drivers, sectorial disaggregation. The forecasts were provided either as useful heat demand or final energy consumption. Five reports contained no forecast of heating demand although most of those five reported the base year heating demand.

Distribution of forecasted changes in heating demand in different Member States is presented in Figure 1. Please note that some countries are omitted due to the lack of required information in their CAs.

Sixteen MSs estimated that heating demand will decrease in the future, whereas six MSs forecasted an increased demand.

Figure 1. Forecasted changes in heating demand (from base year to final year)



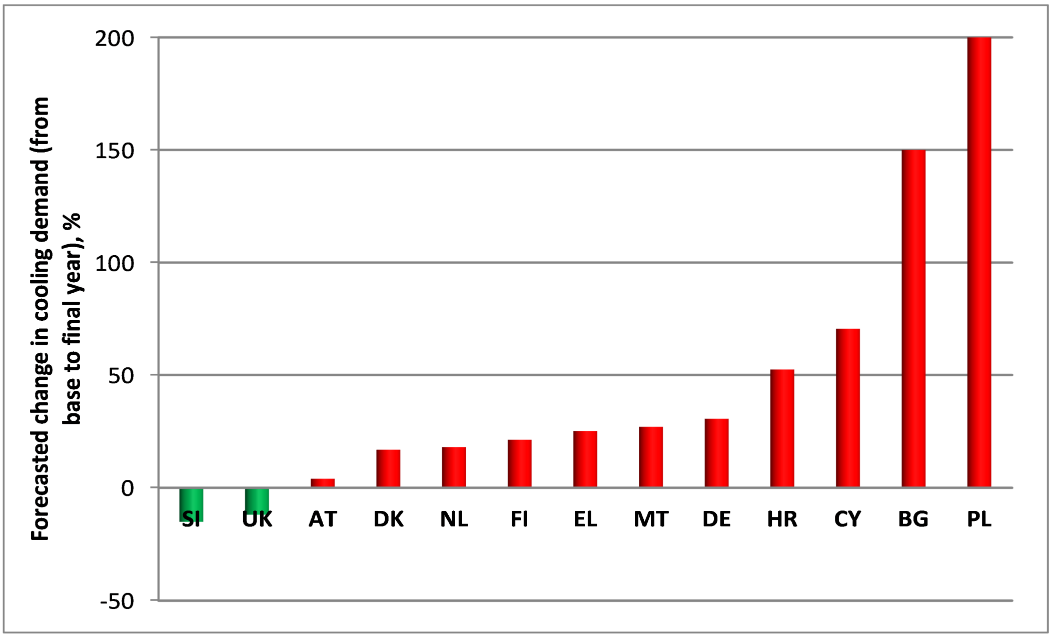
Source: JRC analysis

3.2.6 Projected changes in cooling demand

Cooling demand forecasts were included in those reports which also contained description of current cooling demand (15 out of 28) although with generally lower level of detail compared with the heating demand forecast. Cooling demand was forecasted to increase by 0 to 200 %. UK and Slovenia assumed that cooling demand will decrease.

Distribution of forecasted changes in cooling demand in different MSs is presented in Figure 2. Please note that some countries are omitted due to the lack of required information in their CAs. A large number of reports contained very limited information about cooling demand. Some reports contained just an estimation of the current demand but lacked the forecast of future demand.

Figure 2. Forecasted changes in cooling demand (from base year to final year of the analysis)



Source: JRC analysis

Table 3 presents a summary of heating and cooling demand forecasts in different MSs. It should be noted that some countries omitted some sectors or energy uses from the forecast. Therefore the values presented in this table do not always represent their total future heating or cooling demand. The values of forecasted demands of different countries cannot be compared due to different time horizon. Please refer to the Table 3 for description of sectors evaluated in different reports, time horizons and other details.

Table 3. Heating and cooling demand for final forecast year per Member State.

Member State	Heating demand, TWh	Cooling demand, TWh	Notes
AT	129	2.6	BAU scenario. Forecast of cooling demand in industry was not presented
BE – Fl.	132.2	N/A	
BE – Wa.	65.2	N/A	
BE – Br.	10.5	0.3	
BG	33.1	0.5	
CY	5.5	5.8	
CZ	126.7	N/A	
DE	585	23	Trend scenario. Forecast of heating demand in service sector not presented. Cooling demand forecast in industry only
DK	46.1	11	
EE	not clear	N/A	
EL	67.3	11.9	Only forecast of total heat use in industry is presented, without separation into heating and cooling
ES	N/A	N/A	
FI	73	1.7	
FR	697	N/A	Reference scenario
HR	24.3	3.2	No forecast of cooling demand in industry
HU	8	N/A	Report contains only forecast of DH demand, however, reported values in different parts of report are contradicting
IE	not explained	N/A	Authors seemed to use forecasted values of heat demand evolution but the values are not presented
IT	N/A	N/A	Only forecast of final energy use is presented
LV	18.6	N/A	
LT	7.1	N/A	Demand in DH systems only
LU	5.8	N/A	Only heat demand in buildings. Report also contains incomplete forecast of final energy consumption in industry
MT	0.63	0.89	
NL	172.2	3.9	No data on industrial demand. Cooling is assumed to exist only in non-residential sector
PL	253.6	0.84	
PT	N/A	N/A	No heating and cooling demand forecast in industry. Heating and cooling demand in services and agriculture is presented as a single value
RO	70.1	N/A	
SE	51	N/A	Only forecast of heat supplied through DH networks
SI	13.9	0.17	Cooling only for services sector
SK	39.9	N/A	
UK	429	52	

Source: JRC analysis

3.3 Recommendations for heating and cooling demand forecast in future Comprehensive assessments

— The timeframe of heating and cooling demand forecasts should be made consistent with the timeframe of the cost-benefit analysis. The current requirement for forecast is to cover a 10 year period while a CBA usually covers a longer period.

— It is recommended that all future CAs contain at least the following drivers for heating and cooling demand forecasts: effect of existing energy policies, changes in building stock, population change, changes in GDP, and changes in industry demand.

— Forecasts of all energy demands (heating of buildings, SHW, cooling of buildings, industrial process heat consumption, etc.) should be included

3.4 Best practices for heating and cooling demand forecasts

— The Times model was used to forecast the evolution of the energy system in Greece's report at regional level (NUTS-2) up to 2030. The forecast involved all energy consuming and generating sectors. The forecast of heating, cooling and hot water demand in the residential sector was related to the change of GDP using the equation

$$D_{t+1} = D_t \cdot (1 + G_{t+1})^{\varepsilon}$$

where D_{t+1} is the demand for useful energy for space heating or cooling in the year t+1; D_t is the demand for useful energy for space heating or cooling in the year t; G_{t+1} is the GDP change rate from year t to year t+1; $\boldsymbol{\varepsilon}$ is the elasticity of demand for useful energy for space heating or cooling in relation to the GDP change. This elasticity has been calculated using historical data.

The forecast of the GDP change rate at a nationwide level was derived from forecasts of the Ministries of Greece. The forecast was then broken down at regional level (NUTS 2), using historical data relating to the contribution of each region to the national GDP, assuming that the relevant weight of each region will not change during the time scale of the analysis. Energy demand forecasts in different subsectors were based on similar approaches, but instead of GDP the evolution of added value created in sub-sectors was used.

The forecast of heating demand in the industry was based on different approaches for energy-intensive sectors and for non-energy-intensive sectors. Therefore, a forecast of the demand for natural resources (e.g. tonnes of cement) was made in the sectors of iron/steel, cement, glass, aluminium, ammonia. The demand for energy (and, therefore, heating) needed for the manufacture of a product, was calculated on the basis of existing technologies and the potential future technologies to be implemented within the time scale of the analysis. For the other industrial sectors, the evolution of useful demand was related to the evolution of the added value of the sector.

— In the report of Malta heating and cooling demand forecast was presented up to 2030. Heating and cooling demand forecast in residential sector started from the base year and took into account different factors and assumptions, such as: a) building renovation (it was assumed that renovated houses consume 40 % less energy – assumption adopted from official Maltese studies); b) construction rate of new buildings (rate adopted from Maltese NEEAP and Eurostat data on issued building permits – it was assumed that new buildings consume 50 % less energy); c) changes in hot water consumption were related with population growth.

Heating and cooling demand forecasts in service, industrial and agricultural sectors were based on the results of the report EU Energy, Transport and GHG Emissions trends up to 2050 (reference 2013 scenario)[5]. In particular, changes in value added in different sectors were taken into account during the forecast.

5 EU Energy Transport and GHG Emissions trends to 2050 (European Commission, 2014)

4 Heat map of national territory

4.1 Background

The EED states in Annex VIII (1) that the CA of national heating and cooling potentials shall include a map of the national territory, identifying heating and cooling demand points, existing and planned district heating and cooling infrastructure and potential heating and cooling supply points.[2]

4.2 Results

MSs had to prepare national heat maps containing information about heating and cooling demand and supply points. Since the analysis to be performed by MSs must have had a spatial dimension, geographical distribution of demand and supply elements in the territory of MS had to be presented on the map.

4.2.1 Type of the map

In most reports chloropleth maps were prepared. In such maps predefined areas based on administrative borders (e.g. countries, regions, municipality) are shaded/coloured indicating the value of a specific variable (e.g. energy demand, number of buildings etc.).

In some reports isopleth maps were prepared. In these maps a variable is illustrated on a map as a continuous contour, i.e. a surface that is projected in two dimensions. Areas with the same attribute have the same colour. Compared to the choropleth map this is a more realistic visualization of the variable since there is no abrupt change of the level of the variable between two regions.

One MS provided information about fuel consumption using level of detail of separate buildings.

4.2.2 Resolution

Boundaries of municipalities were the most common way to represent heating and cooling demand of municipalities and conurbations in the heat maps. Boundaries of other territorial units, such as postal code areas or communes, were used as well. Some heat maps used square grids of different dimensions, for instance 1x1 km^2.

Information about heating and cooling demand of industrial zones was commonly represented in the form of points, which is logical given different nature of demand and greater possibility to have it pinpointed. However, some maps represented this information as a distributed heat demand using boundaries of municipalities.

4.2.3 Information presented

Heating demand maps of municipalities and conurbations were present in 21 reports. Heating demand maps of industrial zones were represented in 20 reports. Of these, four reports contained no separate map layers for these two types of consumers. Instead, joint information was presented (containing information about municipalities and conurbations as well as industrial zones in one layer), which limited the usefulness of visualised information.

Some reports contained maps with limited information that is useful for CAs. For instance, instead of containing a map of national territory with municipalities and conurbations with a plot ratio of at least 0.3, they contained a map showing the locations of major cities of a country. Other maps contained information about the location of industrial zones, sometimes applying a threshold of an area (for instance 50 ha) without any reference to annual heating and cooling consumption of those zones. While such maps might be inserted into CA for visualisation purposes, they cannot be treated as a substitute for the maps of national territory containing information specified in EED Annex VIII (c).

Information about geographical distribution of cooling demand was found in fewer reports: 15 with cooling demand of municipalities and conurbations and nine of industrial zones. Of these, five reports presented joint information about cooling demand in buildings and industry.

District heating and cooling infrastructure maps were present in 17 reports. Also, some countries where district heating is widely used did not contain such information. Some reports included information about district heating and cooling infrastructure in the form of inventories instead of the maps.

Ten MSs did not provide information about geographical distribution of heating and cooling supply points. Ten reports contained information about three types (as specified in EED Annex VIII) of heating and cooling supply points: electricity generation installations, waste incineration plants and CHP installations. The remaining nine reports contained information about some of these three types. It should be noted that in some cases the stated reason for omitting representation was the lack of corresponding installations (namely waste incineration plants) in the territory of Member State.

Some MSs included into their maps additional information related to potential heating and cooling supply points, for instance locations of installations participating in EU-ETS. However, such information can only be treated as a supplementary as long as information on heating and cooling supply points covered under EED Annex VIII (c)(iii) is provided in CA.

Although not required by EED Annex VIII, four reports contained map layers about the distribution of renewable energy sources. Some reports also included maps with the information about residual heat supply from industrial installations. This represents additional valuable information for energy planning and as such might be considered to be included as mandatory information in the future comprehensive assessments.

4.2.4 Public access

Some Members States indicated that there is or will be a public web platform in order to facilitate the exploration of the datasets. Links to the public currently available web platforms are:

— Austria(http://www.austrian-heatmap.gv.at/karte/)
— Bulgaria (http://maps.trimbul.com/bulgaria-heatmap/)
— Cyprus (http://eratosthenes.cut.ac.cy/cyheatmaps/)
— France (http://reseaux-chaleur.cerema.fr/carte-nationale-de-chaleur-france)
— Netherlands (http://rvo.b3p.nl/viewer/app/Warmteatlas/v2)
— Romania (http://maps.heatroadmap.eu/berndmoller/maps/30663?preview=true#)
— United Kingdom. Maps, examples of which are presented in the report, do not seem to be available online. Instead, maps for different regions of UK or themed maps are available:
  - England (http://nationalheatmap.cse.org.uk/)
  - Scotland (http://heatmap.scotland.gov.uk/)
  - CHP development map (http://chptools.decc.gov.uk/developmentmap/index.php)

Other countries provided description of interactive maps as well as internet links but they were not functioning during the preparation of this report.

Table 4 summarizes the information that was collected about elements included in the preparation of heat map.

Table 4. General overview regarding the preparation of heat maps (Source: JRC analysis)

MS	Type of map	Resolution	Heating demand		Cooling demand		DHC infra.	Supply points			Other maps (e.g. RES)	Available on web
			Municip. and conurb.	Industr. zones	Municip. and conurb.	Industr. zones		Power gen. install.	Waste inciner. plants	CHP install.		
AT	Isopleth	0.003, 0.06 and 1km² grids	+	+	-	-	+	+	+	-	+	Yes
BE– Fl.	Raster	0.01, 0.09 and 1.44 km² grids	+	+	+		+	+	+	+	+	No
BE– Wa.	Chloropleth	Municipalities	+	+	-	-	-	-	-	-	-	No
BE– Br.	Chloropleth	Statistical areas, communes	+	+	+	-	+	+	+	+	-	No
BG	Chrolopleth	Municipalities	+	+	-	-	+	+	-	-	-	Yes
CY	Choropleth, Dasymetric	Postal code	+	+	+	-	-	+	-	-	+	No
CZ	Points	-	-	-	-	-	+	+	+	+	-	No
DE	-	No information	-	-	-	-	-	-	-	-	-	No
DK	Choropleth	-	+		+		+	+	+	+	-	No
EE	Points	-	-	-	-	-	+	-	-	+	-	No
EL	Chloropleth	Municipalities	+	+	+	-	+	+	-	+	-	No
ES	Isopleth	0.01 km² grid	+		+		-	+	+	+	+	No
FI	Choropleth	Municipalities	+	-	+	-	+	-	-	-	-	No
FR	Chrolopleth	Municipalities	+	+	+		+	+	+	+	-	Yes
HR	Choropleth	Municipalities	+	+	+	-	-	-	-	-	-	No
HU	Choropleth	Municipalities	-	-	-	-	+	-	-	-	-	No
IE	Choropleth	Small areas	+	+	-	-	-	+	+	-	+	No
IT	Choropleth	0.6 km² grid, municipalities	+	+	-	-	+	+	+	+	-	No
LV	Choropleth	Municipalities	+		-	-	-	+	+	+	-	No
LT	-	No information	-	-	-	-	-	-	-	-	-	No
LU	Choropleth	0.063km² grid, municipalities	+	-	-	-	+	-	-	-	-	No
MT	Choropleth	Council	+	+	+	+	-	-	-	-	-	No
NL	Buildings	Buildings	+	+	-	-	+	-	-	-	+	Yes
PL	Choropleth	Municipalities	+	+	+	+	+	+	+	+	-	No
PT	Choropleth	Municipalities, civil parishes	+	+	+	+	-	+	+	+	-	No
RO	Choropleth	1 km² grid	+	-	+	-	-	+	-	-	-	Yes
SE	Choropleth	1 km² grid	+	+	+	+	-	+	-	+	-	No
SI	Points	1 km² grid	+	+	-	-	-	-	-	-	-	No
SK	Points	Municipalities	-	-	-	-	+	-	-	+	-	No
UK	Choropleth	Middle Layer Super Output Area	+		+		+	+	-	+	-	Yes

4.3 Recommendations for preparation of heat map of national territory in future Comprehensive assessments

- Lack of precise specification in EED allows the MSs to submit various layers in different resolutions. It is recommended that the heat map layers should be agreed upon before the next evaluation in 2020, e.g. separate layers for heating and cooling demands and heating and cooling demands of buildings and industry should be presented in separate layers due to the different properties of such demands[6].
- Resolution of the information presented in the maps should generally be increased. The most commonly used method in Comprehensive Assessments to present information about heating and cooling demand – chloropleth map using boundaries of municipalities – does not allow capturing actual distribution of urban fabric and associated heating and cooling demands. Especially, important spacial information becomes lost in the case of municipalities with large territory. A resolution of at least 1 km^2 for high heat demand density areas is needed in order to perform adequate heat linking analysis.
- Instead of plot ratio, heat demand density (kWh/m^2) or linear heat density (kWh/m) should be made the preferred option to identify high demand zones, since they are more accurate (e.g. not climate dependent) than the plot ratio. Plot ratio could be used in the case that heat demand density cannot be established. A more detailed description of the plot ratio and its application should be provided, e.g. in the Annexes.
- Currently EED Annex VIII provides a limited list of potential heating and cooling supply points to be included into a heat map. This list should be expanded with all potential heating and cooling supply points larger than 20 GWh, e.g. industries, IT data centres, and resources, most important of them being renewable energy sources, e.g. geothermal and solar heat.
- The prepared heat maps should be made available to the public on the internet, so that anyone can access them and use them for their analyses.
- In order to provide more information for decision making process, it would be useful to visualize forecasted data on future heating and cooling demand as well. Such visualisation would allow to clearly seeing significant changes, foreseen in heating and cooling demand base and supply sources.

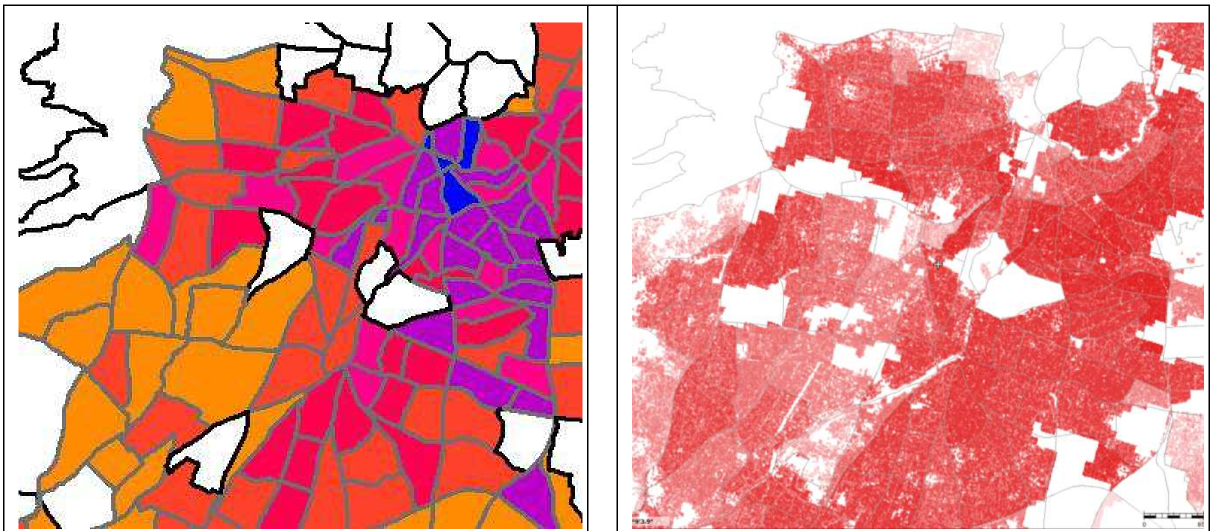
4.4 Best practices for preparing heat maps of a national territory

- The analysis presented in the report of Cyprus has been done at a postal code level, which resulted in a choropleth map with an aggregated value of energy use per zone (postal code area). Dasymetric mapping was used to improve the spatial distribution of the population in order to provide more accurate data during preparation of heat maps. Ancillary data such as land use were employed to improve the disaggregation process by allowing the discrimination of distinct functional areas and respective densities. Energy demand data were redistributed from choropleth map zones (e.g. postal code areas) to dasymetric map zones based on a combination of areal weighting and the estimated population density of each ancillary class. As ancillary data weighting factors, information about built-up area from JRC's Global Human Settlement Map was used. All layers were masked by Corine land uses so that only relevant land use classes were used: e.g. areas marked as industrial zones were excluded from the residential heat maps. The final resolution of the raster map grid was 10x10 m. From the three (space heating, space cooling, SHW) choropleth maps per sector, the final maps were produced. Two fragments of Cyprus heat map are presented in Figure 3. Figure 3a contains a fragment of the city of Nicosia with the

6 Unless industrial installations are integral part of urban fabric and are using low temperature heat, compatible with heat requirement of the buildings.

distribution of heating demand per postal code (chrolopleth map). Figure 3b contains dasymetric map of the same area of the city with the refined distribution of heating demand.

Figure 3. Distribution of heating demand using chloropleth and dasymetric mapping.



a) b)

Source: CY heat map

— A publically available heat atlas of the Netherlands contains a lot of information about different energy consumers and potential heat suppliers. While the map lacks information about heating and cooling supply, it contains information about averaged gas and electricity supply per individual building. Additionally, the map contains a lot of information about all the neighbourhoods of the Netherlands, such as electricity and gas consumption (TJ/a), population count, household count, etc.

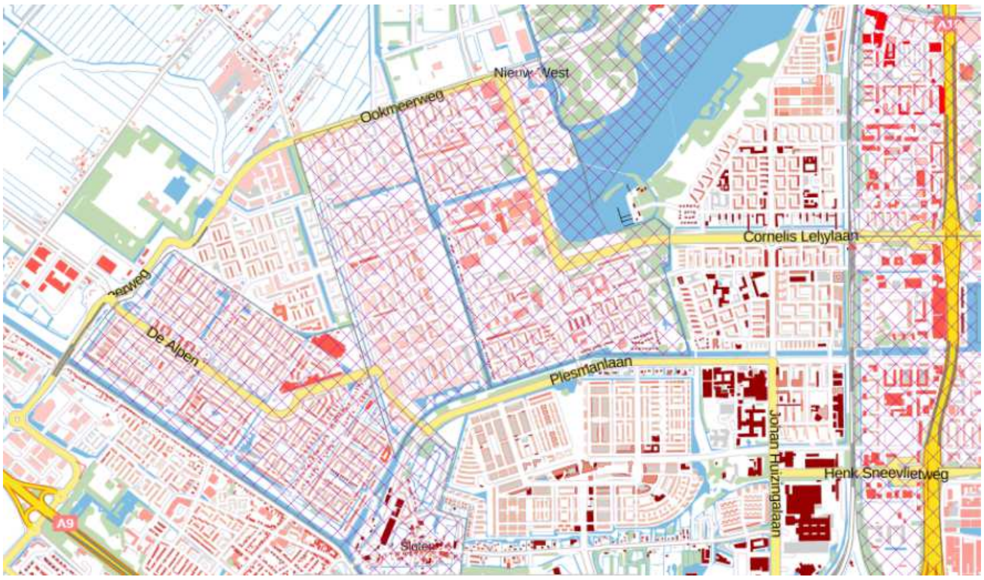
  The map contains layers representing the coverage of district heating networks represented in polygons. Information about connected households per network is also available.

  Information about potential heat sources is also included into the map. The available information includes waste heat from large industrial plants, geothermal energy, biogas and biomass potentials.

  Nevertheless, it should however be noted that the heat map lacks some elements which are required by EED Annex VIII.

  A fragment of the heat map of the Netherlands, showing gas consumption in the buildings and territorial coverage of district heating networks is presented in Fig. 4.

Figure 4. A fragment of the heat map of the Netherlands showing use of natural gas in the buildings and territorial coverage of district heating networks



Source: Heat map of the Netherlands (http://rvo.b3p.nl/viewer/app/Warmteatlas/v2)

5 Identification of the technical potential for HECHP, EDHC, and other efficient heating and cooling technologies

5.1 Background

The estimation of the technical potential relies on the identified heat demand and heat demand forecast. Those elements of the heat demand that could be technically satisfied by efficient solutions, including high efficiency cogeneration, micro-cogeneration and efficient district-heating and cooling should be identified. [2]

5.2 Results

It should be mentioned that there is not a clear definition or direct reference to technical potential in the EED: it just refers to 'identification of demand that could be satisfied by…'. Therefore, MSs were in a position to decide how to tackle and present the information. Although it is not legally binding, the SWD (see references, no.2) defines technical potential as "the theoretical maximum amount of energy that could be produced with efficient heating and cooling solutions, disregarding economic criteria".

For CHP and DHC the technical potential could, in principle, be equal to the whole demand unless some techno-economic criterion is considered (e.g. heat density for DHC). On the other hand, the technical potential for renewables could be constrained by the availability of the resource.

This section first examines whether the technical potential was identified. It then presents the criteria and methodology used to estimate it and it finally compiles the technologies and values of technical potential reported.

Tables 6 and 7 show which CAs provided estimation of the technical potential of different technologies.

Table 5. Technological solutions (related with EDHC) analysed in CAs.

Efficient district networks							
	CHP	**Heat recovery from power plants**	**Heat recovery from industry**	**Biomass**	**Solar**	**Geothermal**	**Heat pumps**
AT	+	+	+	+	+	+	
BE-Fl.	+	+	+				
BE-Wa.							
BE-Br.							
BG	+			+			
CY	+	+		+	+		+
CZ	+						
DE			+				
DK	+		+	+			
EE	+						
EL							
ES	+	+	+	+	+	+	
FI							
FR							
HR							
HU							
IE							
IT	+	+	+	+		+	+
LT	+						

LU							
LV							
MT	+	+	+	+			
NL			+				
PL							
PT	+			+			
RO	+						
SE	+						
SI	+			+			
SK	+			+			
SL							
UK	+	+	+	+			+

Source: JRC analysis

Table 6. Individual technological solutions analysed in CAs. The technologies in italics are required by EED.

Efficient individual solutions						
	micro-CHP	***CHP-industry***	**Biomass**	**Solar**	**Geothermal**	**Heat pumps**
AT		+				
BE-Fl.	+	+				
BE-Wa.						
BE-Br.						
BG						+
CY	+		+	+		+
CZ	+					
DE						
DK	+					
EE	+	+				
EL			+			
ES						
FI						
FR	+					
HR						
HU						
IE	+		+			+
IT	+	+	+			
LT						
LU						
LV						
MT	+	+	+			
NL						+
PL	+	+	+	+		+
PT						
RO						
SE						
SI	+					
SK						
UK	+		+	+		+

Source: JRC analysis

A number of MSs did not identify the technical potential of any technology and in some cases, DHC and CHP were not part of the analysis.

Furthermore, different criteria and methodologies (see Table 8) were used among those MSs which carried out the analysis. The main criteria were:

- environmental restrictions;
- technical constraints;
- applicability of technology in each (sub)sector;
- a priori economic exclusion criteria based on activity (e.g. heat demand below a specific threshold);
- heat demand.

In terms of the time frame, most MSs considered current and future technical potential values.

A great variety of criteria to identify potential areas for DHC were applied, including:

- Based on different heat density threshold criteria e.g.:
  - linear heat density;
  - heat demand density;
  - plot ratio;
  - examined individually for all administrative units.

Some countries did not include a clear description of identification the criteria.

Table 7. Summary of aspects related to technical potential of district networks

Member State	DHC areas identification criteria	Time frame	Technical potential criteria
AT	Heat density	2012-2050[7]; 2012-2025[8]	Energy consumed/produced Technical restrictions
BE-Fl.	Heat density	Unclear	Heat demand
BE-Wa.	Not applied. Linear heat density of 2000 kWh/m is mentioned as a critical threshold	2012-2030	n.a
BE-Br.	Linear heat density: 2000 kWh/m	2012-2030	Ratio of total consumption
BG	Unclear	Unclear	Projections
CY	Heat demand density (>5 kWh/m²)	2013-2050	Resources, demand, technical restrictions, linear heat density
CZ	None	2012-2025	Environmental constrains, availability of fuel source, demand
DE	Heat density and number of buildings	2012-2040[9]; 2012-2050[10]	n.a
DK	Not described. Maps with energy density provided (MWh/km²)	2030 for DC; 2050 for DH and CHP	Unclear
EE	Unclear. Apparently linear heat density	2008-2050 for DH	Demand, linear heat density
EL	None	n.a	Spatial analysis (for biomass and NG)
ES	Plot ratio (> 0.3)	2015-2050	Demand, heat density
FI	Linear heat density (>0.5 GWh/km) mentioned, not used	n.a	n.a

[7] for residential and service sectors
[8] for industrial sector
[9] residential sector
[10] industrial sector

FR	None	2008-2020	Heat density (not qualified), exclusion of buildings heat by decentralised electrical heating system
HR	None	n.a	Demand, population, climate conditions, existing infrastructures
HU	Not described	2015-2025	Not described
IE	Linear heat density (>3; 5; 10 MWh/km)	2015-2040	Suitability of connecting to a heat network, linear heat density
IT	Linear heat density (> 2.5 MWh/a for EDHC)	2013 and 2023	Heat demand and technical constraints
LT	None	n.a	n.a
LU	Plot ratio and heat density	n.a	n.a
LV	Plot ratio (> 0.3)	2014-2030	Plot ratio in selected regions
MT	None	2013- 2030	Technical feasibility based on local climatic conditions and resources
NL	Not described	n.a	n.a
PL	Heat density	2013-2044	Replacement of existing CHP with new plant, connection of existing DH networks with CHP
PT	None	n.a	n.a
RO	Plot ratio (> 0.3)	2013- 2030	Potential of reconnection and new connections (residential sector); CHP based on percentage of total DH potential
SE	Not described	2010-2030	Individual studies, modeling
SI	Not described	2014-2030	n.a
SK	None	n.a	n.a
UK	Plot ratio (> 0.3)	2012 - 2030	Geographic availability of resources, environmental and technical restrictions

Source: JRC analysis

Finally, Table 8 presents a summary of the technical potential figures, which can be expressed as a) installed capacity or b) energy produced/demand covered, identified by MSs. Is should be noted that the figures included in Table 9 cannot be compared directly. They were estimated on the basis of different assumptions for technology sets, concepts and methodological approaches and they refer to different base years and different end uses.

Table 8. Technical potentials of efficient heating and cooling solutions identified in CAs

Member state	CHP (TWh/a)	DH (TWh/a)	DC (MW)	Other efficient solutions (TWh/a)	Reference year
AT	57	22-63	-	WHR: 2.82 (>100 °C), 8.46 (<100 °C) Biomass: 31 (in 2020) Geothermal: 1.9 Waste incineration: 2 Solar thermal: 37.7 Efficient cooling: 0.3	2025
BE-Fl.	0.187 in 86 large scale industrial enterprises	Same as heat demand	-	Micro-CHP: same as heat demand	2035
BE-Wa.	0.529	-	-	Waste heat from industry: 1.8-3.4	2012
BE-Br.	0.14-0.28 (residential and tertiary)	-	-	-	-
BG	-	-	-	-	-
CY	0.038 – 7.81[11]	1079 (with CHP)	-	Solar: 7.5 Heat Pumps: 5.4 Heat Pumps-Split units: 5.2 Resistance heaters: 3.0 Solid biomass- eff. boilers: 0. 5 Municipal waste–eff. boilers: 0.041 Livestock/Ind. waste–eff. boilers: 0.038	2013

[11] depending on the fuel used

CZ	-	-	-	-	-
DE	-	-	-	WHR industry: 87	-
DK	-	44.2	2866	-	2050
EE	0.51	0.51	-	-	-
EL	-	-	-	-	-
ES	-	-	-	-	-
FI	-	-	-	-	-
FR	215 (total)	232.6 (total)	-	-	2020
HR	-	-	-	-	-
HU	-	-	-	-	-
IE	-	1.6	-	-	2015
IT	66.7	10.7 (NG); 2.1 (waste inciner.); 2.6 (biomass)	-	-	-
LT	-	-	-	-	-
LU	-	-	-	-	-
LV	0.53	0.45	-	-	2030
MT	Case studies only	Case studies only	Case studies only	-	2013
NL	-	-	-	Heat pumps: 20.83; Other RES: 19.4 - 30.5	-
PL	150	203	-	Individual heat pumps: 108.1	2025
PT	-	-	-	-	-
RO	16.7	22.3	-	-	2013
SE	-	-	-	-	-
SI	9.5	-	-	-	2035
SK	-	-	-	-	2014
UK	46 – 401 [11]	3 – 276 [11]	-	Air to water heat pumps: 334 Solar thermal + gas boilers: 322 Ground source heat pumps: 267 Biomass boilers: 167 Solar thermal+ biomass boilers: 160	-

Source: JRC analysis

Although, the applicability of HECHP was not analysed in most cases, MSs claimed that all the cogeneration plants (including both industrial and district heating) are considered high efficiency installations.

Moreover, one MS provided a detailed analysis at plant level showing that cogeneration struggle to reach the primary energy savings (PES) threshold for district heating applications. The reason being that heat could only be sold to the DH network during the cold season; hence, the plant could not be efficiently operated the rest of the year.

5.2.1 Energy efficiency potentials of district heating and cooling infrastructure

The efficiency of district heating and cooling infrastructure is determined by levels of pipe thermal insulation, flow and return temperatures. Losses in the distribution network are proportional to the density of the network.

Table 9 summarises the energy efficiency potentials of DHC networks identified by MSs as required in point f) of Annex VIII to the EED.

Table 9. Energy efficiency potentials of DHC networks identified in CAs

Member State	Current distribution losses	Potential reduction in distribution losses
AT	10 % on average	NA
BE – Fl.	NA	NA
BE – Wa.	Correction factors used in simulation but not reported	Correction factors used in simulation but not reported
BE – Br.	5 – 20 %	1 - 4 % (theoretical assumption)
BG	23.7 % (2.77 TJ/km)	10 % (1.17 TJ/km)
CY	NA	NA
CZ	10.8 %	3.6 %
DE	12 – 13 %	2 - 3 % (theoretical assumption)
DK	24 %	NA
EE	16 – 26 %	9 – 21 %
EL	NA	NA
ES	NA	NA
FI	8 – 9 %	1.6 - 2.4 %
FR	7.5 – 14 %	NA
HR	13 % (in the city of Karlovac)	5 – 7 % (theoretical assumption)
HU	NA	NA
IE	10 %	NA
IT	16 %	10 %
LT	15.6 %	3.5 %
LU	NA	NA
LV	15.4 %	5.5 - 11.3 GWh/y
MT	NA	NA
NL	NA	NA
PL	12.90 %	9.3 %
PT	NA	NA
RO	25 %	4.3 - 6.4 %
SE	15 %	8 %
SI	NA	NA
SK	NA	NA
UK	NA	NA

Only 13 MS included an estimation of the energy efficiency potential of the distribution networks. As shown in

Table 9, a number of MS stated current losses in distribution networks but did not estimate the potential for improvement.

5.3 Recommendations for identification of technical potential of HECHP, EDHC and other efficient heating and cooling technologies in future Comprehensive assessments

The Directive should provide explanation on how to estimate and report the technical potential. To be able to extract the results of the CAs in a comparative way, as a minimum, the following should be reported on a common basis:

— It should be reported per technology assuming maximum penetration, per specific scenario or per other techno-economic constraints. This definition will differ per technology for example, renewables have resource and land-use based restrictions while heat networks have demand-based restrictions. Market related restrictions in the estimation of technical potential should not be applied.

— Future CAs should make a distinction between HECHP and CHP, which is not evident in the current reports. For example, a CHP meeting peak demand of DH network might not qualify as HECHP, since it is not properly sized. Non high-efficiency CHP should be excluded from the technical potential.

— Agree on a minimum list of technologies/heat sources to examine. We propose that CHP, DHC, waste heat from industry, geothermal, solar heat, heat pumps to be analysed as a starting point.

— Specify how the potential will be reported (in terms of share of demand satisfied by each technology, energy saved or power installed).

5.4 Examples of best practices for identification of technical potential of HECHP, EDHC and other efficient heating and cooling technologies in MS's reports

— The Cyprus' report assessed the technical potential as the theoretical maximum amount of energy that could be produced with efficient heating and cooling solutions, disregarding all non-engineering constraints such as economic or market barriers. Thus, the followings aspects were taken into account:

  o Resource availability. This was a limiting factor for some efficient solutions. It was a restricting element in the case of solutions based in renewable resources and recovered resources as for example waste heat.

  o Technical considerations that intervene in the energy conversion and/or use processes (efficiencies, temperature ranges, etc.).

  o Demand size. This parameter was taken into account in order to determine the maximum amount of useful energy that is required. In those cases in which the availability of the resource was higher than the demand, it delimited the heat amount considered within the technical potential of a solution. Similarly, in those cases in which there was no relevant restriction on the availability of the resource, for example air heat pumps or micro-cogeneration, the technical potential was sized as a function of the demand.

— Analysis of the existing demand and supply in Italy's report made it possible to identify the demand points best placed for being served by CHP systems and to assess the amount of cogenerated capacity and energy that are applicable at those demand points. This allowed the identification of a theoretical maximum value or technical potential for cogeneration development, meaning the greatest share of heat demand which, based on technical constraints, can be met by CHP installations, regardless of any economic considerations. In detail, the technical potential has been assessed through the following steps:

- Selection of sub-sectors best suited for cogeneration, in light of certain indicators and technical constraints (amount of the heat demand by customers, presence of installations already in operation in the sub-sector, required temperature of the heat, heat/electricity ratio, installation constraints and so on);
- Establishment of the size of the cogenerator and simulation of its operating conditions at the typical demand point of the sub-sector by applying specific performance indicators obtained from the installations in operation at similar demand points.
- Estimate the maximum amount of cogenerated heat and electricity technically obtainable in the sub-sectors. Extrapolation of the case study results to the whole reference sub-sector.

— In UK's report the technical potential of the heat supply solutions was calculated independently of each other with no reference to economic factors. Therefore, the technical potential of a particular solution represented a maximum technically possible deployment of the technology irrespective of costs. In addition to the annual heating consumption, the type of demand point (DH scheme, non-domestic sector or dwelling type) and the existing heating system and fuel type were also taken into account. A number of simplifying restrictions on technology/property combinations were assumed due to insufficient information and data quality:

- Buildings with a heat consumption below 4 MWh/a, which comprise only about 0.5 % of total heat consumption, were considered not be suited to high-efficiency solutions but only to electric heating.
- Data on geographic availability of gas proved to be inconsistent therefore, assumptions were made; micro-gas CHP cannot be installed in dwellings with no gas supply within the postal code area. Further, for all non-domestic buildings, it was assumed that gas will be available and therefore individual gas CHP can be installed.
- Individual dwellings or non-residential buildings currently heated with electricity will continue to be heated with electricity. This assumption does not apply to district heating systems.
- No individual domestic biomass boilers can be installed in smoke control zones. For district heating and non-domestic applications a biomass plant can be installed in such zones.
- No gas micro-CHP, gas boilers, biomass boilers, GSHPs or solar thermal will be installed in individual flats for practical and safety reasons.
- No heat pumps, solar thermal systems or district heating schemes will serve industrial sites. Due to unavailability of data on the grade of heat required by individual industrial sites, it was assumed that they require higher grade heat that cannot be provided by these technologies.

Only directly usable grades of heat were considered for waste heat from power stations, waste incinerators and industry. The use of waste heat by other industrial sites was not analysed. It would require specific site by site information, including grades and quantity of heat.

6 Cost-Benefit Analysis

6.1 Background

A CBA is an analytical approach used to appraise an investment decision in order to assess the welfare change attributable to it [4]. Conducting a CBA implies assessing the changes in cost and benefits between baseline and alternative scenarios and integrating them in a common analysis framework to compare them along time and arrive to conclusions about their profitability at society level. [2]

Once the technical potential of the solutions has been assessed, the next step is to conduct a CBA to identify those parts of the technical potential that can economically be met by efficient heating and cooling solutions.

6.2 Results

This section of the synthesis report aims at describing whether the general principles of the CBA as described in Annex IX, Part 1 of EED were followed by Member States for the identification of economic potential of efficient heating and cooling options in their CAs.

6.2.1 Main steps and considerations of the CBA analysis

Some remarks in terms of the methodological approach, scope of the analysis and considerations of the CBA under Annex IX, Part 1 of EED are presented in this sub-section. Not all CAs include clear description of the analysis performed. In some cases CBA was not conducted at all.

Regarding an integrated approach to demand and supply, different scopes of analysis were considered:

— On the demand side, Table 10 describes the sectors and end uses considered:

  - In terms of sectors covered, most MSs analysed efficiency potentials for residential and tertiary sectors; large number of MSs also included industry demand and a few MSs included agriculture demand.
  - In terms of end uses, most MSs analysed efficiency potentials for heating demand and few of them also include cooling demand.
  - In some cases the scope of the analysis was not clear.

Table 10. Demand side: scope of analysis

	Sectors				Uses	
	Households	**Tertiary**	**Industry**	**Agriculture**	**Heating**	**Cooling**
AT	+	+	+		+	+
BE-Fl.	+	+	+	+	+	
BE-Wa.	+	+	+		+	+
BE-Br.	+	+	+		+	+
BG	+	+	+		+	
CY	+	+	+	+	+	+
CZ	+	+	+		+	
DE	+	+	+		+	
DK						
EE						
EL	+	+	+	+	+	+
ES	+	+	+	+	+	+
FI						
FR	+	+	+	+	+	+
HR						
HU						
IE	+	+			+	

IT	+	+	+		+	
LT	+	+	+	+	+	
LU	+	+	+		+	
LV	+	+	+		+	
MT	+	+	+		+	+
NL	+	+	+	+	+	+
PL	+	+	+		+	
PT						
RO	+	+			+	
SE						
SI	+	+			+	
SK						
UK	+	+	+	+	+	

Source: JRC analysis

— On the supply side, Tables 12 and 13 describe the scope of technological options considered:

- o The range of efficient supply options for district networks is wider (meaning that it includes heat recovery and/or renewables) in some MSs than others. Some countries only considered cogeneration from natural gas as a heat source for the district heating network. A few countries did not conduct a CBA of efficient district heating networks.
- o Within efficient individual supply options, cogeneration (including micro-CHP and CHP in industry) is analysed by a majority of MSs. A number of countries did not assess the potential of micro-cogeneration in the areas of low heat demand density. Other individual supply options (renewables, heat pumps, etc.) are analysed by limited number of MSs.

Table 11. Supply side: scope of analysis for efficient district networks.

Efficient district networks							
	CHP	**Heat recovery from power plants**	**Heat recovery from industry**	**Biomass**	**Solar**	**Geothermal**	**Heat pumps**
AT	+		+	+	+	+	+
BE-Fl	+	+	+				
BE-Wa	+	+	+	+			
BE-Br	+	+	+				
BG	+			+			
CY	+	+		+	+		+
CZ	+	+		+			
DE	+						
DK							
EE							
EL	+	+	+	+			
ES	+	+	+	+	+	+	
FI							
FR	+						
HR							
HU							
IE	+	+	+	+		+	+
IT	+			+		+	
LT	+			+			
LU							
LV	+	+	+	+			
MT			+				
NL	+	+	+			+	
PL	+			+			

PT							
RO	+						
SE	+	+	+	+			
SI	+			+			
SK							
UK	+	+	+	+			+

Source: JRC analysis

Table 12. Supply side: scope of analysis for efficient individual solutions.

Efficient individual solutions					
	Cogeneration	**Biomass**	**Solar**	**Geothermal**	**Heat pumps**
AT	+	+	+		+
BE-Fl	+				
BE-Wa					
BE-Br	+				+
BG					+
CY	+	+	+		+
CZ	+	+			+
DE	+				+
DK					
EE					
EL					+
ES	+	+	+		
FI					
FR	+	+			
HR					
HU					
IE	+	+			+
IT	+				
LT					
LU	+	+			+
LV					
MT	+	+			
NL			+		+
PL	+	+	+		+
PT	+				
RO					
SE	+	+			+
SI	+	+			
SK					
UK	+	+	+		+

Source: JRC analysis

Regarding the methodological approach used in the CAs (more information in Tables 14, 15 and 16):

— About half of the MSs structured their CBAs using an approach that largely corresponded to the elements of Annex IX Part I of EED.

— Other MSs provided the output from previous studies (with differing methodological principles to those indicated by Annex IX Part I of EED) or did not provide enough information to draw a conclusion.

  — Some MSs did not conduct a CBA.

— System boundaries to frame the CBA were defined differently by MSs:

  o One national boundary, possibly aggregating multiple geographical boundaries and even excluding some areas based on defined criteria (Czech Republic, France, Ireland, France, Romania and Sweden).

  - Several system boundaries, either grouped based on a specific criterion such as energy density or individual administrative areas (UK, Cyprus, and Spain followed this approach).
  - Individual installations as case studies to be extrapolated to a national level (e.g. Germany, Malta)
- Baseline scenarios differed between MSs in terms of complexity and assumptions but in most cases they were designed taking into account the most likely evolution of demand drivers (economy, population, etc.), technologies, fuel availability and relevant energy and climate policies.
- The alternative scenarios were based on different ranges of potential supply sources.
- Economic potential is not clearly defined in the EED and was consequently reported differently. Some MSs estimated economic potential using comparison between different technologies and others did not. Furthermore, the units used for reporting differed as well, e.g. GW or GWh.
- Regarding the method for the calculation of cost-benefit surplus:
  - Long-term costs were considered by most MSs although not clearly reported in some cases.
  - NPV criterion was considered by the majority of MSs. Nonetheless, some countries did not clarify which criterion was used or did not conduct a CBA as described in the EED.
  - Several countries only performed a financial analysis, thus external costs were not accounted for.
  - The time horizon varied from 2030, 2040, 2044 and 2050. One country had a time horizon until 2020 which is shorter than the required 10 years. Some MSs did not specify the time horizon clearly.
- Calculation and forecast of prices and other assumptions for the economic analysis were considered by MSs although they were not clearly reported in some cases.
- Inventory of effects: most MSs considered capital, operating and fuel costs. In some cases, other external effects were also considered: mainly, environmental and health effects and CO_2 costs. Avoided transmission network use and avoided electricity network losses were included in one case.
- Sensitivity analyses were conducted by more than half of the MSs, with a variety of aspects considered. They concerned mainly different energy prices, discount rates and other variable costs.

Table 13. Overview of main steps and considerations of CBA.

Member State	System boundaries	Baseline (BAU) construction	Alternative scenario selection
AT	Individual cases for 38 primary and 30 secondary region types	No. Comparison of technology options	Combination of all relevant technological solutions; 9 individual technologies, 6 grid based technologies and 6 grid-based CHP technologies
BE-Fl.	Heat density of heat map cells (i.e. 1200m)	No	Two scenarios: a) DH networks using waste heat and b) DH networks using heat from CHP
BE-Wa.	CBA at installation level in subsectors	Conventional technology in sectors	12 heating scenarios and 2 cooling scenarios in the service sector
BE-Br.	CBA was done at installation level in subsectors	Conventional technology in sectors and four priority areas	Use of an applicability matrix for tech and subsectors
BG	Unclear. Report describes different conflicting criteria	High-efficiency technologies are compared to conventional technology	HE solutions are compared to the basic model that produces only heat. HECHP and HEDH (only in combination with HECHP)
CZ	Whole country	BAU assumed non-existence of economic stimuli for investors to implement and operate CHP sources.	Two scenarios: CHP and high-CHP. They differed in assumed level of penetration of CHP technologies
CY	Five system boundaries covering national demand	Evolution of technology share by sector	Centralised (14) and individual (13) solutions
DE	Sample CHP plants for individual CHP. Town clusters for DH CHP. Individual buildings allocated to 40x40 cell grids used them to form clusters	Technology for individual CHP in residential and service sectors. Policy aspects for CHP in industry. No baseline was established for DH CHP	Technology for individual CHP and policy for industry
DK	Not described	Fossil scenario	District heating, district cooling and CHP
EE	Not described	Not described	At least, cogeneration as centralised solution
EL	System boundaries were not established. The CBA was done at national level	It assumes that the total energy demand for space heating is covered by conventional oil-fired boilers	Yes, for different alternative scenarios
ES	Based on heat consumers which were grouped based on demand density and heat amount consumed	Based on existing technologies to cover heating and cooling demand in residential, tertiary and industrial sectors	Waste heat from industry, power plants and waste incineration. Renewable energy sources and CHP installations
FI	Not identified	No	No
FR	National level CBA covering national demand	Conventional gas boiler (90% yield)	Individual and centralised CHP solutions
HR	n.a.	No	Conservative and optimistic HECHP scenarios
HU	Not described	No	No
IE	Aggregation of high heat density zones (35-85 zones depending on threshold used). 5-13% of national heat demand coverage	Boilers and electric heating	Centralised (6) and individual (6) solutions
IT	Only for EDHC potential, 2.5 MWh/m as linear heat density threshold	Comparison of cost of efficient heating and cooling options	HECHP scenarios by sector. Three scenarios for EDH i.e. natural gas; waste incineration and biomass.

LT	Existing district heating networks	No	Only for DH system analysis. Heat demand in areas outside existing DH zones was not included.
LU	Not used	No	No
LV	4 cities for detailed CBA for analysis of CHP potentials and 8 cities for increasing the share of district heating	No particular baseline was constructed. Current status of DH network and CHP was used as such	Four scenarios to improve existing DH systems in cities
MT	Individual CBA extrapolated to national level	Same technologies as base year	Individual solutions (4)
NL	Not described	Fuel and CO2 prices will change in accordance with the 'new policies' scenario of the IEA's World Energy Outlook 2013	Yes, but the analysis does not focus on the requirements
PL	2372 zones (municipalities/city boroughs) covering national demand	Evolution of technology and fuel availability	Centralised (3) and individual (5) solutions
PT	Individual cases for 10 CHP plants with different capacities	No	No
RO	National level CBA with national demand coverage	Evolution based on energy planning and improved heat networks	Centralised solution (1)
SE	National level	Baseline made of alternative solutions to CHP, DHC	1. EDH; 2. HECHP in DH; 3. industrial CHP and 4. DC
SI	Areas having more than 120 TJ/km2 heat demand density and a set of particular buildings	Current heat production in DH systems and the analysis of two particular cities	Yes. High-efficient cogeneration, including micro-cogeneration
SK	Not used	No	No
UK	52 zones covering national demand	Current technology replaced by similar one with improved efficiency	Centralised (8) and individual (6) solutions

Source: JRC analysis

Table 14. Overview of main steps and considerations of CBA.

Member State	Long term prices	NPV/other criteria	Time frame	Financial analysis	Economic analysis	External costs considered	Sensitivity analysis
AT	Yes	NPV	2012-2025	Yes	No	No	Yes
BE-Fl.	No	NPV	Unclear	Unclear	Unclear	No	Yes
BE-Wa.	Yes	NPV	2012- 2030	Yes	No	No	Yes
BE-Br.	Yes	NPV	2012-2030	Yes	No	No	No
BG	Yes	NPV	2014-2025 (Unclear)	No	Unclear	Environmental	No
CZ	Yes	NPV	2013-2025	Unclear	3 scenarios with different level of CHP penetration	Environmental	Yes
CY	Yes	NPV	2013-2050	Yes	Yes	Environmental and health	Yes
DE	Yes	NPV, electricity production costs, costs of energy unit	2014-2043	Yes	Yes	No	No

DK	No	Not specified	2030 for DC; 2050 for DH and CHP	Yes	Yes	Not provided	No
EE	No	Not specified	n.a	No	No	No	No
EL		NPV, IRR, benefit to cost ratio and discounted payback time	2010-2030	Yes	Yes	Environmental and health	Yes
ES	Yes	NPV	2015-2050	Yes	Yes	Environmental and health	No
FI	No	No	n.a	No	No	No	No
FR	Yes	NPV, IRR and PES	2008-2020	Yes	No	CO2 costs	Yes
HR	No	Energy savings	n.a	No	No	No	No
HU	No	No	2015-2025 for DH	No	No	No	No
IE	Yes	NPV, CO2 emission reduction and PES	2015-2040	Yes	Yes	Environmental and health	Yes
IT	Yes	NPV, IRR	2013-2023	Yes	No		No
LT	Yes	Unclear	Unclear	Unclear	Unclear	No	No
LU		Price of energy unit produced	2012-2030	Yes	No	No	No
LV	Yes	NPV, IRR	2015-2040	Yes	Yes	Environmental	Yes
MT	Yes	NPV, IRR and PES	2013- 2030	Yes	Yes	Environmental, health and macro-economic externalities	Yes
NL	Yes, but not described clearly	Energy savings, CO2 emissions, cost-effectiveness	2014-2020, 2030 and 2050 for different cases	Unclear	Unclear	Environmental	Partially
PL	No	NPV	2013-2044	Unclear	Unclear	CO2 costs and emission reduction costs. Data not provided	Yes
PT	No	IRR, payback	n.a	Unclear	Unclear	No	Yes
RO	Yes	NPV, and marginal cost of PES	2013- 2030	Yes	Yes	No	Yes
SE	Yes	Not described	2010-2030	No	Yes	CO2 costs	Yes
SI	Yes	NPV	2014-2042	No	Yes	Environmental	Yes
SK	No	No	2014-2025	No	No	No	No
UK	Yes	NPV	2012 - 2030	Yes (1 sensitivity scenario)	Yes	Environmental, health; transmission network use and electricity network losses	Yes

Source: JRC analysis

Table 15. Economic potentials identified per Member States.

	CHP	District heating	District cooling	Other relevant efficient solutions (TWh/year)	Reference year
AT	18.8 TWh/a[12]	40 TWh/a	n.a	-	2025
BE-Fl	59.5 MWe in large scale industry	n.a	n.a	-	2035
BE-Wa	0.458 TWh/a	7.05 TWh/a	n.a	-	2036
BE-Br	140-280 MWe	n.a	n.a	-	2030
BG	n.a	n.a	n.a	-	-
CY	0.04 - 1.08 TWh/a	1.079 TWh/a (DHC)	n.a	Heat Pumps - Split units: 5.3; Solar: 3.1; Heat Pumps: 2.9; Municipal waste - Efficient boilers: 0.04	2013
CZ	n.a.	n.a.	n.a	-	-
DE	Residential and service sectors: 207 TWhth and 182 TWhe; Industry: 91 TWhth and 40 TWhe	n.a	n.a	Individual CHP in residential sector: 3 Individual CHP in service sector: 3	2050
DK	0.0	0.0	2211 MWe[13]	Heat recovery: 2.5	2050
EE	62.1 MWth (thermal capacity)	62.1 MWth (thermal capacity)	n.a	-	-
EL	n.a	n.a	n.a	-	-
ES	n.a	n.a	n.a	Overall heat potential: 56; Overall cooling potential : 7	-
FI	n.a	n.a	n.a	-	-
FR	11.65 TWh/a	n.a	n.a	-	2020
HR	1.53 (conservative case) and 4.62 (optimistic scenario)[14]	n.a	n.a	-	2030
HU	n.a	n.a	n.a	-	-
IE	Not clear	0.01 TWh/a	n.a	-	2015
IT	18.9	4.1 TWh/a	n.a	-	2013
LT				-	
LU	Industrial CHP: 425 GWh [15]	1606 GWh in 2012 and 1170 GWh in 2030 [15]	n.a	-	2030
LV	47 GWh/year	96 GWh/year	n.a	Biogas: 0.136	-
MT	0.006 TWh/a	n.a	n.a	-	2013
NL	n.a	n.a	n.a	RES: 11.6-12.7	Unclear
PL	79.98 TWh/a	86.46 TWh/a	n.a	Individual heat pumps: 65.8	2015
PT	86.39 TWh/a	n.a.	n.a	Heat pumps: 65.8	2025
RO	Natural gas CHP: 15.1 TWhth	20.07 TWhth	n.a	-	2030
SE	23.5 TWh/a	51 TWh/a	n.a	-	2030
SI	None	n.a	n.a	-	2035
SK	13.5 TWh/a	n.a	n.a	-	-
UK	n.a	15 TWh/a	n.a	Individual solutions: 116	-

Source: JRC analysis

[12] of which 0.5 is new HECHP and 1.5 is non-high efficiency CHP
[13] Electrical capacity
[14] Results based on trends not on CBA
[15] Based on financial analysis

6.3 Recommendations for preparation of CBA and identification of economic potential of HECHP, EDHC and other efficient heating and cooling technologies in future Comprehensive Assessments

The review has revealed disparities in methodological approaches, scope of the analysis and reporting of results across MSs' CAs. In order to ensure a homogeneous basis for policy design on efficiency in heating and cooling at EU level, the European Commission should consider the possibility of working in collaboration with MSs in an attempt to tackle the main challenges identified, sharing best practices and providing a more detailed description of the scope of the analysis and reporting standards. In this respect, and similarly to the recommendation made in the previous section related to the technical potential, some aspects that could be better defined are the following:

— Provide a clear definition of the term and clarify the connection between the CBA explained in Annex IX and the CA explained in Annex VIII or have concrete instructions in one Annex;

— Provide templates and units to report economic potentials, data on prices and other assumptions used;

— Provide clear definitions of economic and financial analysis and specify which kind of analysis and under which circumstances should be conducted;

— The CA assessments ought to investigate accelerated introduction of thermal insulation of buildings too. This is to ensure that the most cost-efficient mix of efficient/low-carbon heating and cooling solutions and thermal insulation levels of buildings are implemented while meeting decarbonisation targets.

One of the main challenges of the analytical process is its significant data requirements, the complexity involved in data processing[16] and the consideration of the geographical and time dimensions. In order to facilitate the analysis in the future and to avoid punctual and isolated efforts, several actions could be considered such as promoting the development and use of modelling tools for the analysis. These tools would facilitate the process of updating the information and would provide powerful analytical capabilities to identify optimal combinations of efficient solutions.

6.4 Examples of best practices in the execution of CBAs and identification of economic potential of HECHP, EDHC and other efficient heating and cooling technologies

— In the report of Germany the CBA was performed from both and economic and business perspective. Two rather different approaches were used to perform CBA of individual CHP and district heating CHP.

  The CBA for individual CHP installations was performed for selected sample technologies and building types. The results of such sample CBA calculations were later extrapolated to determine CHP potentials of the whole country. Overall, the calculations were performed using 14 typical CHP plants and their parameters. It involved the comparison of: a) CHP b) gas boilers and c) lower capacity gas boilers coupled with the renovation of the building. Heat pumps were analysed as an option only in newly constructed buildings. In the residential sector, four types of single family houses and four types of apartment buildings were analysed. Finally, in the service sector, the CBA was performed for hospital, office building and commercial business.

  The CBA for district heating CHP was done using a different approach. Towns in Germany were divided into nine categories based on population numbers and

[16] including different demand sectors; end uses and supply solutions

geographical location. Then, economic viability of district heating CHP was determined using detailed data on 41 model towns belonging to those nine categories. The results from these case studies were then applied to the whole country and the total potential of DH CHP was determined. Contrary to the CBA for individual CHP installations, the DH CHP solution was not compared to the alternative scenarios. Instead, DH CHP in particular case was treated as economically viable if the total costs were lower than the revenue from customers.

In the case of industry, CBA was performed for 6 different types of CHP installations. The dependency of electricity generation costs on annual load hours was determined for each type of installation. This was compared with electricity price levels (both economic and business case) of 7 types of industrial installations thus determining conditions when particular CHP installation would be economically feasible.

— In Ireland's report a range of scenarios have been developed based on the results of the heat mapping exercise and a review of the available technologies. Thus, different system boundaries and technology options were analysed. These scenarios were compared with a heat demand and supply baseline which included energy efficiency improvements, growth in population and economic activity. The supply baseline assumed heat provision from counterfactual heat technologies which customers currently use, predominantly boilers.

The costs and benefits of each scenario were estimated and forecasted into the future. These forecasts included all the costs and benefits of future use of these heating technologies, regardless of which economic actors bear the costs or enjoy the burdens. The costs and benefits taken into account included the costs of installing and operating new heating infrastructure, the costs of conventional heat provision avoided and any environmental benefits. The economic NPV of each scenario was calculated. These NPVs provided a measure of the net benefits of adopting these technologies to the economy as a whole. On this basis, the most economically advantageous scenarios were identified.

— In the report of Cyprus the input data used to define alternative scenarios was the forecast of the heat demand, the technical potential of each efficient solution and a set of assumptions. Each scenario was built to evaluate the effects of expanding each technical solution to their maximum extent (i.e. taking into account its technical potentials and other considerations) with the aim of identifying the economic potential of that solution and respecting technical potential cap.

In cases when the technical potential of a solution is lower than the demand, the rest of the demand was covered by other technologies. This adjustment was used to make the baseline and the alternative scenario comparable. The gap of demand was covered by the scaled down mix of technologies of the baseline scenario. Thus in each system boundary the number of alternative scenarios was equal to the number of technically viable solutions identified during the technical potential evaluation.

7 Drafting strategies, policies and measures that may be adopted up to 2020 and up to 2030

7.1 Background

The Comprehensive Assessment should contain a description of strategies, policies and measures that may be adopted up to 2020 and 2030 to realise the identified potential for additional HECHP in order to meet the identified heating and cooling demand that could be satisfied by HECHP and by district heating and cooling. Such a description should contain, where appropriate, proposals to increase the share of cogeneration in heating and cooling production, develop efficient district heating and cooling infrastructure, encourage waste heat generating installations and heat consumers to be located and connected to the local district heating and cooling networks and so on.

7.2 Results

A general overview of strategies, policies and measures that may be adopted up to 2020 and up to 2030, identified in different reports, is summarised in Table 17.

Table 16. General overview of strategies, policies and measures principles identified in different reports

Member State	Strategies, policies and measures cover period till 2020 and 2030	Related with		
		CHP	district heating and cooling	other efficient heating and cooling technologies
AT	No	No	No	No
BE – Fl.	No	No	No	No
BE – Wa.	Yes	Yes	Yes	No
BE – Br.	Yes	Yes	Yes	No
BG	Existing policies described	Yes	Yes	Yes
CY	Yes	Yes	Yes	Yes
CZ	Yes	Yes	Yes	No
DE	Yes	Yes	No	No
DK	till 2020	Yes	Yes	No
EE	Recommendations for	No	Yes	No
EL	Yes	Yes	No	No
ES	No	No	No	No
FI	No	No	No	No
FR	Existing policies described	Yes	No	No
HR	Existing policies described	Yes	Yes	No
HU	No	No	No	No
IE	Recommendations for	Yes	Yes	No
IT	Existing policies described	Yes	Yes	No
LV	Yes	Yes	Yes	No
LT	No	No	No	No
LU	No	No	No	No
MT	Yes	Yes	No	No
NL	Existing policies discussed	Yes	Yes	No
PL	Yes	Yes	Yes	No
PT	Current policy described	Yes	No	No
RO	Yes	No	Yes	No
SE	Yes	No	Yes	No
SI	Existing policies described	Yes	Yes	No
SK	Existing policies described	Yes	Yes	No
UK	Existing policies described	Yes	Yes	No

Source: JRC analysis

Some of the analysed reports provided only limited information about strategies, policies and measures that may be adopted up to 2020 and 2030. Some reports only describe existing or even already expired policies. Often reports include insufficient or no description about contribution of such policies and strategies for achieving goals as identified during CBA up to 2020 or even 2030.

Only a limited number of reports included descriptions of recommendations to construct relevant policies. Of these, a significant part relates with general energy efficiency improvement measures in buildings or energy systems, such as energy audit campaigns, replacement of old boilers with condensing ones, installing metering equipment and so on. Few proposals and suggestions were directly related with the subject matter of EED Annex VIII (g)(i-vi).

7.3 Recommendations for drafting of strategies, policies and measures that may be adopted in short and medium term in future Comprehensive assessments

— Development of relevant strategies, policies and measures as a part of CA, should be strengthened. Current reports sometimes contain only a general discussion about the heat market or energy efficiency improvement measures with no indication on how they will contribute to the realisation of the goals as set in EED Annex VIII (g). Since this can be identified as a recurring issue of most reports, more detailed and explicit guidance, suggestions and examples could be made available to the parties preparing CAs.

— Given the limited progress of cogeneration in many Member States (see Section 7), the reason for this should be evaluated. For instance, is it due to weak policies or new market situation? Depending on the outcome, new types of policies, measures and strategies might be needed to realise the identified potential at European level.

7.4 Best practices on drafting of strategies, policies and measures that may be adopted in short and medium term in MS's reports

— In order to chart the strategy to achieve identified potential of heating and cooling solutions the report of Belgium's Brussels region performed the following actions:

  o SWOT analysis of the technical and environmental context of the Brussels region in order to identify the technical and economic factors that support/weigh against the development of cogeneration and district heating within region.

  o establishing technical, legal, economic or financial courses of action that would unlock the economic potential of cogeneration and district heating and cooling. These actions were grouped into: economic and financial (encourage the system of third party investment, keep green certificates for CHP, etc.), legal (introduce a mechanism for feed-in electricity purchase, adopt network gas pricing, etc.), technical (encourage localised storage, etc.) and other (arrange training for building and construction professionals, introduce mechanism of evaluation of costs and benefits for new urban development projects, etc.).

  mapping out these courses of action along a timeline up to 2030. In order to do so, for each identified action the following variables were identified: timescale of implementation (short to long), ease of implementation (easy to difficult), potential impact (low to high) and the need of subsidies (no or yes).

8 Reporting the share of high-efficiency cogeneration and the potential established and progress achieved under 2004/8/EC

8.1 Background

Member States have to report the share of high efficiency CHP, the potential established and progress achieved related to the requirements of 2004/8/EC.

8.2 Results

Table 17 summarizes the reported values by each Member State.

Table 17. Reported values on share of HECHP and potential and progress achieved by Member States

Member State	CHP capacity	Fuel	Share (electric)	Progress achieved		
				Capacity increase (base to final year)	Base Year	Final Year
AT	n.a	n.a	n.a	n.a	2005	n.a
BE-Fl	1875 MWe		0.84	n.a	2007	2014
BE-Wa	n.a	n.a	n.a	n.a	2005	n.a
BE-Br	n.a	n.a	n.a	n.a	n.a	n.a
BG	n.a	n.a	n.a	n.a	2008	n.a
CY	2.3 MWe	Biogas	n.a	10.9	2006	2015
CZ	10550 MWe; 20640 MWth	Brown coal 54%, anthracite 17%, NG 18% RES and other fuels 11%	0.14	n.a	2005	2014
DE	21500 MWe	NG 53%, coal 22%, lignite 6%, waste 7%, biomass 2%, petroleum 1%, others 9%	0.15	14 TWh	2005	2013
DK	5600 MWe	n.a	0.62	n.a	2007	2013
EE	574 MWe; 1060 MWth	n.a	n.a	n.a	2007	-
EL	234.7 MWe	n.a	n.a	183.7 MW	2010	2015
ES	927000 MWe	NG > 80%	Unclear	n.a	n.a	2013
FI	6300 MWth		0.36	n.a	2009	2010
FR	6336 MWe	NG 53%, others 47%	n.a	n.a	2008	n.a
HR	n.a	n.a	n.a	n.a	n.a	n.a
HU	1700 MWe; 3100 MWth	n.a	0.13	n.a	2009	2013
IE	311 MWe	NG 91.8%, oil 2.8% biogas 2%, biomass 1.7%, solid 1.7%	0.07	2.8 Mwe	2013	2014
IT	2600 MWe; 3100 MWth	CHP (elec): 67% NG, 12% fossil fuels, 13% RES, 8% other. CHP (heat): 60% NG, 15% fossil fuels, 13% RES, 10% other	0.13	8.2 TWhe	2004	2013
LT	n.a	n.a	n.a	n.a	n.a	n.a
LU	407 MWe	mainly NG	n.a	n.a	2005	2016
LV	3005 MWe; 5231 MWth	86% NG	0.48	n.a	2010	2020
MT	n.a	n.a	n.a	n.a	n.a	n.a
NL	8900 MWe	NG 94%, others 6%	0.42	n.a	2008	n.a

PL	8600 MWe; 24800 MWth	21% NG, 14% coal, 7% lignite, 6% oil, 12.9% biomass, 7.1% biogas	0.2	n.a	2007	2010
PT	1759 MWe	n.a	0.17	n.a	2010	2014
RO	4433 MWe; 10046 MWth	Mainly NG	0.11	Unclear	2007	2013
SE	17.5 MWe	52% RES, 27% fossil, 7% waste heat, 14% other	0.1	17	2005	2011
SI	n.a	n.a	n.a	n.a	n.a	n.a
SK	2820 MWe; 7350 MWth	21% NG,15% hard coal, 7% lignite,6% Oil,12.9% Biomass,7.1% Biogas	0.14	n.a	2006	2014
UK	5200 MWe	n.a	n.a	4700	2000	2014

Source: JRC analysis

Main conclusions from the information reported by MSs and included in Table 18 are:

— Most of the MSs reported the total installed capacity of CHP but not its share in the total energy or electricity/heat mix;

— In those cases that the progress achieved in the implementation of HECHP was reported, timeframes vary considerably.

JRC compared EUROSTAT data on CHP electricity generation in the EU from 2004 to 2014, see Table 19 generation increased from 10.5 % to 11.7 % in the period 2004 to 2013[17], however, the estimation for 2014 fell to 10.5 % [4]. The electricity generation from cogeneration was 347 TWh in 2004 and increased to 386 TWh in 2012, but in 2014 the estimate has fell to 335 TWh.

CHP increased as a percentage of the electricity generation in about half of the Member States from 2004 to 2014. The largest growths could be seen in Belgium, Ireland, Greece, Lithuania, and Slovakia, whereas the largest decreases were found in France, Hungary, Romania, and United Kingdom. The economic potentials identified by Member States in 2011 were usually quite far from being reached in 2014, see Table 19.

Hence, it can be concluded that less progress has been achieved until 2014 than expected, and it questionable the cogeneration potential identified will be realised too.

Table 18. Share of CHP in gross electricity generation and gross electricity generation by CHP. This is compared to potential for CHP identified in 2011 and in this CA. The colour coding for 2014 indicates the change from 2004 (green – increase, orange – same, red – decrease).

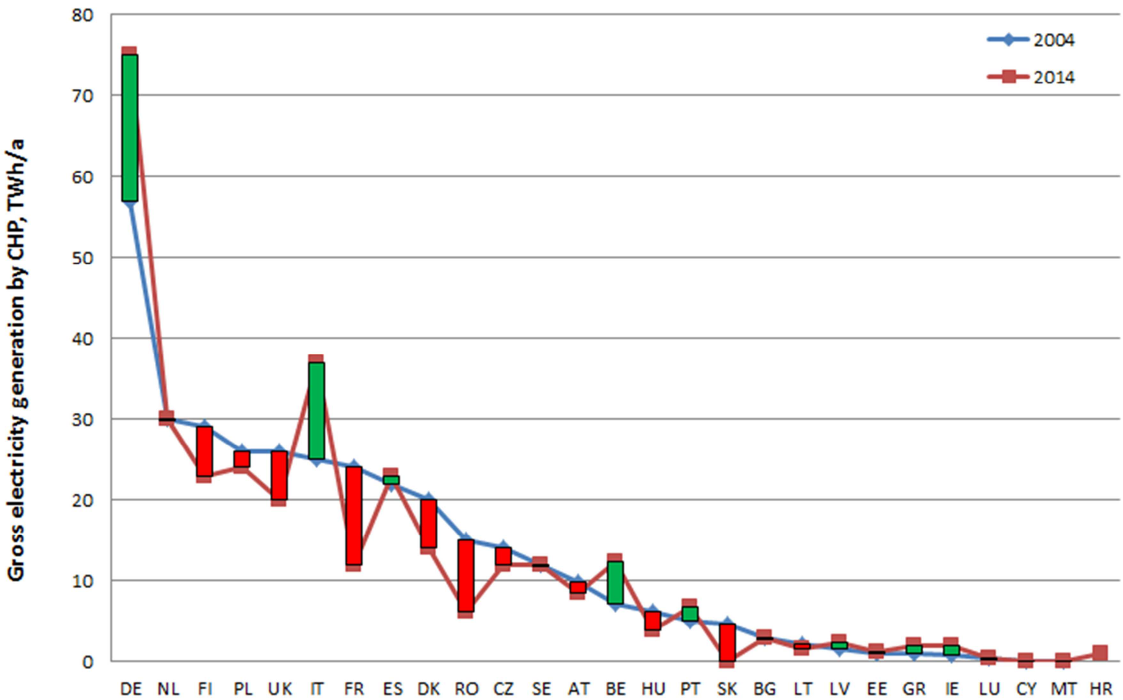
Member State	**2004**		**2014**		**Economic potential identified in 2011 for year 2015 / 2020**	**Economic potential identified in this CA for year 2020**
	% CHP	*TWh*	*% CHP*	*TWh*	*TWh*	*TWh*
EU	— 10.5	347	10.5	335.0		
AT	— 15.2	9.8	13	8.5		18.8
BE	— 8.4	7.2	17.1	12.4		
BG	— 7.3	3.0	6.2	2.9	5 / 22	
CY	— 0	0.0	1.5	0.1	0.6 / 1.1	1.1
CZ	— 16.4	14	13.7	12	14 / 17	-
DE	— 9.3	57	11.9	75	- / 176	200
DK	— 50	20	44.3	14	22 / 25	0.0
EE	— 9.9	1.0	10	1.2	2.1 / 2.1	-
EL	— 1.5	0.9	3.7	1.9	5.8 / 6.3	-
ES	— 7.9	22	8.4	23	42 / 39	-
FI	— 34	29	33.8	23	26 / 24	-

[17] Data for 2014 is estimated by EUROSTAT.

FR	— 4.1	24	2.1	12	18 / 19	12
HR	— -	-	6.3	0.9	-	1.5
HU	— 18.2	6.1	13	3.8	6.1 / 6.1	-
IE	— 2.6	0.7	7.4	1.9	3.3 / 8.3	-
IT	— 8.1	25	13.1	37	28 / 39	19
LT	— 11.6	2.2	33.2	1.5	-	-
LU	— 10.6	0.4	12.8	0.4	-	0.4
LV	— 32	1.5	47.5	2.4	-	0.0
MT	— 0	0.0	0	0.0	0.1 / 0.1	0.0
NL	— 29.5	30	29	30	78 / 85	-
PL	— 17	26	15.1	24	56 / 55	80
PT	— 11	5.0	12.9	6.8	11 / 13	86
RO	— 26.4	15	9.3	6.1	-	15
SE	— 8.1	12	7.9	12	15 / 14	24
SI	— 6.4			0.6	3.2	-
SK	— 15.3	4.7	-	-	1.7 / 1.2	14
UK	— 6.7	26	6	20	85 / 130	-

Source: JRC analysis

Figure 5. Gross electricity production by CHP in 2004 and 2014 per MS



Source: JRC analysis. Based on data from EUROSTAT

8.3 Recommendations for reporting the share of high-efficiency cogeneration and potential established and progress achieved during previous reporting period in future Comprehensive assessments

— Member States should improve the reporting of progress to show the progress in realising the HECHP potential. The process could benefit from the use of a standardised template.

— Based on EUROSTAT data, the realisation of HECHP potential in several Member States is low. The reasons should be evaluated.

8.4 Best practices on reporting the share of high-efficiency cogeneration and potential established and progress achieved during previous reporting period in MS's reports

— In the Italian report the share of high efficiency cogeneration was identified in a number of stages:

  - Based on statistical data capacities, energy production, technology employed as well as location of Italian power plants.
  - Based on Eurostat data capacities and energy production in CHP plants.
  - According to EED, it is important to identify the share of electricity truly in cogeneration installations. The method set out in Annex I for calculating the amount of "electricity from cogeneration" was applied to determine the quantity of electricity produced in cogeneration mode.
  - The information from the applications submitted to the Italian Energy Services Operator (State owned company, responsible for qualification and verification of plants) was used to identify the subset of plants meeting the restrictive criteria set out in Annex II to EED.

9 Estimation of primary energy savings

9.1 Background

Primary energy savings associated with identified potentials should be given in the assessments. Besides, primary energy saving could also be used as an additional criterion in the evaluation and decision making process.

9.2 Results

The EED Annex VIII 1(i) requires carrying out an estimate of the primary energy to be saved. The results included in this section are directly related to the scope and the methodologies applied to identify potentials in the previous sections.

In principle, the MSs would report how much primary energy savings could be achieved by the realization of each energy efficient scenario.

Primary energy savings were mainly reported in the following two ways:

— For a scenario compared to the baseline;

— For a specific high efficiency technology compared to another conventional one.

Table 19 provides a summary of primary energy savings presented by Member States. Overall, estimation of primary energy savings is scarce and the applied methodology is inconsistent. It should be noted that the figures are not comparable, since they are based on different methodologies, definitions and scope.

Table 19. General overview of the main elements related to Primary Energy Savings

Member State	Scope	Relative/ absolute	Indicative Scenario 1	Indicative Scenario 2
AT	Regional level	Absolute	If economic potential of DH, savings: 0.62 TWh in buildings; 0.25 TWh in industry; 1.25 TWh increase in overall primary energy consumption	-
BE-Fl	Not provided	-	-	-
BE-Wa	Regional level	Relative	CHP: 4 155 GWh; waste energy utilisation: 93.12 GWh	-
BE-Br	Not provided	-	-	-
BG	Not provided	-	-	
CY	For each examined technology scenario	Relative	-	-
CZ	2 scenarios	Absolute	CHP scenario: 8.86 TWh	High CHP scenario:13.36 TWh
DE	Not provided	-	-	
DK	For 5 different scenarios. No primary energy savings associated with DH, DC or CHP are presented	Relative	Wind scenario: 190 PJ in savings	-
EE	Not provided	-	-	-
EL	Not provided	-	-	
ES	Not provided	-	-	-
FI	For CHP scenarios	Relative	Replace old CHP plants : 14%	Replace old heavy fuel oil boilers: 27%
FR	National level	Absolute	CHP: 2.8 Mtoe	
HR	2 scenarios for new HECHP	Relative	Conservative scenario: 1.35 TWh/a (in 2030)	Optimistic scenario: 4.07 TWh/a (in 2030)
HU	Not provided	-	-	
IE	For specific scenarios	Relative	Heat networks: 2.39 TWh	Alternative low carbon technologies: 5 TWh

IT	National level	Absolute	Incremental CHP: 6.7 TWh; Incremental DH: 3.3 TWh	-
LT	Not provided	-	-	-
LU	Not provided	-	-	-
LV	Scenario: technical potential of reconstruction of DH in 14 locations	Relative	158 GWh/a	-
MT	For specific case studies	Relative	-	-
NL	Not provided	-	-	-
PL	Not indicated	-	-	-
PT		-	-	-
RO	For each examined technology scenario	Absolute	CHP achievement of 55 % in 2020 and 95 % in 2030: 71.1TWh	-
SE	National level	Relative	CHP: 10.4 TWh by 2030 DH: 5.9 TWh in 2030	-
SI	Expansion of DH systems and increase in energy efficiency of infrastructure in two cities	Absolute	221 GWh	-
SK	Not provided	-	-	-
UK	Not provided	-	-	-

Source: JRC analysis

9.3 Recommendations for estimation of primary energy savings in future Comprehensive assessments

— Primary energy savings should be used as an instrument to promote energy efficiency policies. Therefore, Member States should estimate and report those for scenarios evaluated.

— The EED does not indicate what primary energy savings the MSs should evaluate, which creates confusion and non-harmonized reports. A more precise definition should be agreed upon. It is proposed that the estimation should be based on primary energy savings achieved compared to the baseline. The latter should be based on the expected evolution from continuing with existing energy policies.

9.4 Examples of best practices on estimation of primary energy savings in MS's reports

— Expected primary energy needs in Austria's report were calculated for the most cost-effective technology mix identified in the CBA. This information was then used to calculate greenhouse gas emissions. The primary energy consumption and GHG emissions were compared with the primary energy consumption and emissions of a reference technology. In the area of households and businesses this was a local gas boiler. In regions not connected to the gas grid it was an oil boiler. Primary energy savings and GHG emission reduction in the given scenario compared to the reference technology were then calculated. In doing so, the temperature-adjusted efficiency reference values in accordance with Commission Implementing Decision 2011/877/EU were used. In industry, a comparison was made with the most common technology for pure heat supply, or if cogeneration plants were already the only technology in use, with a gas boiler.

GHG emissions were calculated using the emissions factors. The emissions generated as a result of the additional potential for cogeneration technologies were calculated on the basis of fuel consumption for both electricity and heat, and not separately. For grid-bound technologies, emissions produced by the peak load boiler were also taken into account. For the reference technology, it was assumed that the volume of electricity generated was produced separately by power stations.

In industry, due to the inclusion of industrial waste material, more than one fuel is used for certain technologies. In these cases, the emissions were calculated in line with the share of each fuel in total energy consumption.

— It is stated in the Swedish report that there is great inconsistency with regard to the primary-energy weighting of various kinds of energy. A primary-energy factor (PEF) of 0 means that the fuel that is used does not consume any primary energy, since the resource 'has already been used'. Forestry residues (trees and branches), for example, could be regarded as a residual product that would otherwise have gone to waste and thus has a PEF of 0. It is, however, possible to argue that such resource should have a primary-energy factor of between 0 and 1, since there is a value that could have been used elsewhere.

The choice of primary-energy factors is of great importance for the final result in terms of improving energy efficiency in the event of district-heating, district-cooling or cogeneration expansion. Among a number of primary-energy weighting principles Swedish study chose to use change-impact principle, since it also takes account of long-term production changes.

The 'change impact' principle studies the impact of changes in the use of energy carriers, for example electricity or district heating, from the system perspective. In order to do this, several assumptions needed to be made, among others on how the use of the energy type in question will be affected in the future by changes in relation to current energy consumption.

For the purposes of performed analysis, it has been assumed that electricity has a relatively high primary-energy factor (of nearly 3), but this will fall over time as electricity production becomes more efficient and less intensive in its need for primary energy in the longer term. District heating was weighted by a factor of approximately 0.7, and combustible waste and most biofuels have a primary-energy weighting of nearly zero, since they are assumed to be residual products. The fact that district heating itself has a primary-energy weighting that is clearly greater than zero is because the principle was based on the impact of a change.

10 Estimate of public support measures to heating and cooling

10.1 Background

The Comprehensive Assessment should provide an estimate of public support measures to heating and cooling with the annual budget and identification of the potential aid element, if such support is planned.

10.2 Results

General overview of public support measures to heating and cooling, identified in different reports, is summarised in Table 20.

Table 20. General overview of public support measures identified in different reports

Member State	Description of public support measures to heating and cooling	Related with supporting realisation of potentials identified in CA	Identification of annual budget	Identification of potential aid element
AT	Absent	No	Absent	Absent
BE – Fl.	Absent	No	Absent	Absent
BE – Wa.	Absent	No	Absent	Absent
BE – Br.	Included (partially)	Yes	Absent	Yes
BG	Absent	No	Absent	Absent
CY	Proposals	Yes	Yes	Yes
CZ	Current measures	No	Yes	Yes
DE	Absent	No	Absent	Absent
DK	Absent	No	Absent	Absent
EE	Yes	Current measures only	Yes	Yes
EL	Current measures	No	Yes	No
ES	Absent	No	Absent	Absent
FI	Absent	No	Absent	Absent
FR	Yes	Current measures only	Yes	Yes
HR	Absent	No	Absent	Absent
HU	Yes	No	Yes	Yes
IE	Absent	No	Absent	Absent
IT	Absent	No	Absent	Absent
LV	Absent	No	Absent	Absent
LT	Included (partially)	No	Yes	No
LU	Absent	No	Absent	Absent
MT	Absent	No	Absent	Absent
NL	Current measures	No	Yes	Yes
PL	Absent	No	Absent	Absent
PT	Absent	No	Absent	Absent
RO	Absent	No	Absent	Absent
SE	Absent	No	Absent	Absent
SI	One current measure	No	Absent	Absent
SK	Absent	No	Absent	Absent
UK	Absent	No	Absent	Absent

Source: JRC analysis

Only two reports contained information about identified public support measures to heating and cooling related directly to the CA performed and another two reports discussed how existing measures support the implementation of the identified potential. A few reports incorporated measures and their budget estimates came from external studies, which often used other means than CBAs to identify the economic potential of DHC. Other reports contained only descriptions of currently applied public support measures which have no identified relationship with the results of the Comprehensive Assessment.

The reason why so many MSs omitted to present this part of the CA is unclear. Possible reasons could be that MSs needed more time to evaluate how the results from this CA would match other energy policy measures already in place.

10.3 Recommendations for estimation of public support measures in heating and cooling in future Comprehensive assessments

— The reasons for the absence of estimates of public support measures to heating and cooling in the majority of reports should be investigated. Depending on the outcome of investigation different actions would need to be taken.

10.4 Best practices on estimating public support measures in heating and cooling in MS's reports

— The CA of Cyprus revealed that most analysed technology solutions which demonstrated positive economic NPV (ENPV) also had a positive financial NPV (FNPV). Hence, such solutions are commercially viable and they do not require financial support. However, some solutions, while having positive ENPV also demonstrated negative FNPV. Thus the amount of financial support to make FNPV positive for such solutions was estimated. Also, in some cases ENPV of technology solutions were often similar, but with different primary energy savings. In these situations authorities can choose to support technology solutions that are more beneficial for their overall energy policy goals, e.g. to achieve greater primary energy savings and/or increase the share of renewables in the energy mix.

11 Conclusions

The Article 14 of the Energy Efficiency Directive obliges all Member States to perform a Comprehensive Assessment on their potential for application of high-efficiency cogeneration and efficient district heating and cooling, containing the information as set out in the Annex VIII of EED. The Member States were supposed to have submitted their notifications by the end of 2015.

JRC was responsible for the review of the technical aspects of the national notifications. All notifications have been reviewed.

Assessments of the high-efficiency cogeneration and efficient district heating potentials were performed in most notifications. Efficiency improvements of the existing district heating networks were analysed by 14 Member States. Significant economic potentials of high-efficiency cogeneration and efficient district heating and cooling were identified in many Member States.

The Member States assessed most of the elements of the Energy Efficiency Directive Article 14 (and the Staff Working Document), but in many cases several elements were missing. The assessments differed significantly in terms of approaches and how data were reported. Hence, a reliable comparison of potentials identified between Member States could not be performed.

The wording of the Energy Efficiency Directive Article 14 is several cases imprecise in describing how the assessments should be performed, so an update of the wording is recommended.

The approaches in analysing and reporting vary greatly between Member States. This is partially due to the often imprecise wording of the Article 14, and because Member States often pursued their own approaches rather than following the (non-binding) guidelines of the Staff Working Document [2]. Hence, a comparison of results between Member States is often difficult.

A problem often encountered by Member States was the lack detailed data for the heating and cooling sector, which reduced the accuracy of the analyses.

The share of cogeneration has increased in half of the EU Member States since 2004 according to EUROSTAT data. The economic cogeneration potential identified by Member States in 2011 has in most cases not been achieved.

Member States did mostly not report on new strategies, policies and measures. Instead, many Member States chose to explain the existing strategies, policies, and measures.

Although, the assessments contain several weaknesses, it is also evident that Member States have become more conscious of their energy efficiency potentials in the heating and cooling sector. If these weaknesses would be addressed in the next iteration of assessments in 2020, the benefits will be further enhanced.

Hence, it is recommended that the assessments will be repeated in 2020 as foreseen by the Article 14 of Energy efficiency Directive. However, they should be based on a more harmonised set of data, more standardized implementation the assessments, and use a reporting template.

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List of abbreviations and definitions

CA	Comprehensive assessment
CBA	Cost-Benefit Analysis
DC	District Cooling
DH	District Heating
EDHC	Efficient district heating and cooling
EED	Energy Efficiency Directive
ENPV	Economic Net Present Value
EU	European Union
FNPV	Financial Net Present Value
GDP	Gross Domestic Product
GHG	Green House Gas
GSHP	Ground Source Heat Pumps
HECHP	High-Efficiency Combined Heat and Power
HP	Heat Pump
IRR	Internal Rate of Return
LAU	Lower Administrative Unit
MS	Member States
NEEAP	National Energy Efficiency Action Plan
NPV	Net Present Value
NREAP	National Renewable Energy Action Plan
NUTS	Nomenclature of territorial UniTs for Statistics
PES	Primary Energy Savings
RES	Renewable Energy Sources
SHW	Sanitary Hot Water
SWD	Staff Working Document

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Publications Office

doi:10.2760/368839

ISBN 978-92-79-88815-1